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Bioventing Pilot Test
Final Report
Site ST14, Fuel Loading Area
Carswell AFB, Texas

August 1993

AU380

AQ M01-02-0478

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August 11, 1993

Chris Hobbins
Brooks Air Force Base
Bldg 624W, AFCEE/ESRR
San Antonio, Texas 78235

Subject: Bioventing pilot test final report (draft)
Site ST14
Carswell AFB, Texas

Dear Chris:

Enclosed are six copies of the subject draft report. This report describes the pilot test activities and presents the results of the soils investigation and as-built drawings and specifications for the installed pilot unit. Included as appendices are the work plan, the pilot test interim report, and the laboratory report. Note that the laboratory report is a revision of the report previously submitted (table 1 was corrected). Also note that a final version of the operations and maintenance manual for the pilot system is included as an appendix to the pilot test interim report. Two copies of this operations and maintenance (O&M) manual are included in this submittal. I suggest you forward one copy of the O&M manual to Carswell to replace the draft we left with them upon completion of field activities.

Please call if you have any questions or comments.

J. David Highland

J. David Highland, P.E.
Project Manager

xc: Doug Downey, ES-Denver

DRAFT
Bioventing Pilot Test
Laboratory Results
Site ST14, Fuel Loading Area
Carswell AFB, Texas

Contract F41624-92-D-8036

Prepared for

Air Force Center for
Environmental Excellence
Brooks AFB, Texas

Prepared by

Engineering-Science, Inc.
Austin, Texas

August 1993

CONTENTS

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Contents, continued Page

FIGURES

TABLES

SECTION 1

INTRODUCTION

This report summarizes the results of an *in situ* bioventing pilot test for treatment of fuel-contaminated soils and a subsurface soils investigation at the petroleum, oil, and lubricant (POL) tank farm (site ST14) at Carswell Air Force Base (AFB), Texas. It also describes the remedial design of the long-term pilot system for the site.

This report is divided into four sections including this introduction. Section 2 describes the activities performed at the site to obtain data for designing the pilot system and characterizing the existing contamination. Results and conclusions of this site contamination investigation and characterizations are described in section 3. Section 4 summarizes the data necessary for designing the pilot system and presents the as-built design and specifications of the system. Appendix A contains the AFCEE approved work plan; appendix B is the report on interim pilot test results; appendix C is the report on laboratory results; appendix D contains the lithologic logs and vent well construction details; and the as-built drawings and specifications for the pilot test system are in appendix E.

SECTION 2

INVESTIGATION ACTIVITIES

PILOT TEST ACTIVITIES

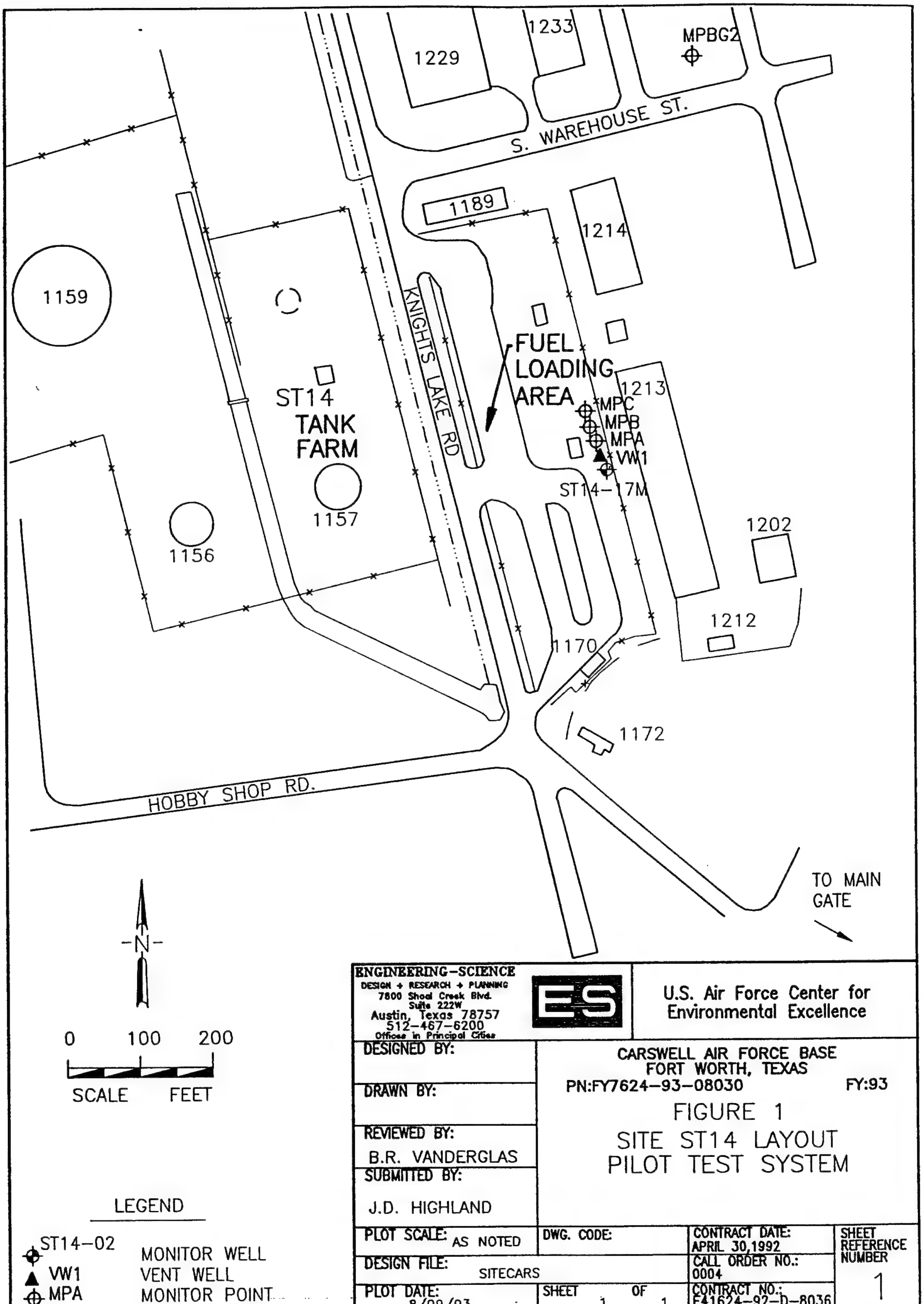
The purpose of this section is to summarize the work that was performed by Engineering-Science (ES) at site ST14 during the bioventing pilot test. The results of the preliminary testing and pilot system construction are more fully discussed in the pilot test report in appendix B. The primary activities performed during the bioventing pilot test were siting and construction of a central air injection vent well (VW) and four vapor monitoring points (MPs), an *in situ* respiration test, an air permeability test, a soil respiration test, and installation of a long-term bioventing pilot system.

Site Layout

Siting of the central VW and vapor MPs was based on historical soil gas and groundwater data which indicated potentially heavy hydrocarbon contamination in the vicinity of monitoring well ST14-17M. Soils in this area were expected to be oxygen depleted (<2 percent) by the probable high levels of fuel hydrocarbons. The three vapor MPs were planned to be located within a 40-foot radial distance of the central VW based on the relatively shallow depth of contamination and the anticipated soil types. A fourth MP was planned for construction approximately 300 feet north of the central VW to measure background levels of oxygen and carbon dioxide. The soils in the planned background location were found to contain high levels of hydrocarbons, so a new background MP (MPBG2) was constructed in clean soils approximately 500 feet north-northeast of the central VW. The locations of the central VW and the MPs were changed from those sited in the work plan because of potential hazards from nearby underground utilities. Figure 1 shows the site layout for the bioventing pilot test. The spacing of the MPs was also changed because the driller was concerned about underground utilities. The maximum radial distance for the MPs (excluding background) was extended to 45 feet from the central VW. Figure 2 shows the as-built locations of the pilot test system.

Air Injection Vent Well

Details of the air injection vent well construction are presented in section 4 of this report. The VW was installed in predominantly clayey soils, where hydrocarbon contamination was indicated at all sampling depths. These soils had some gravel,



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DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93
DRAWN BY:	FIGURE 1
REVIEWED BY: B.R. VANDERGLAS	SITE ST14 LAYOUT PILOT TEST SYSTEM
SUBMITTED BY: J.D. HIGHLAND	

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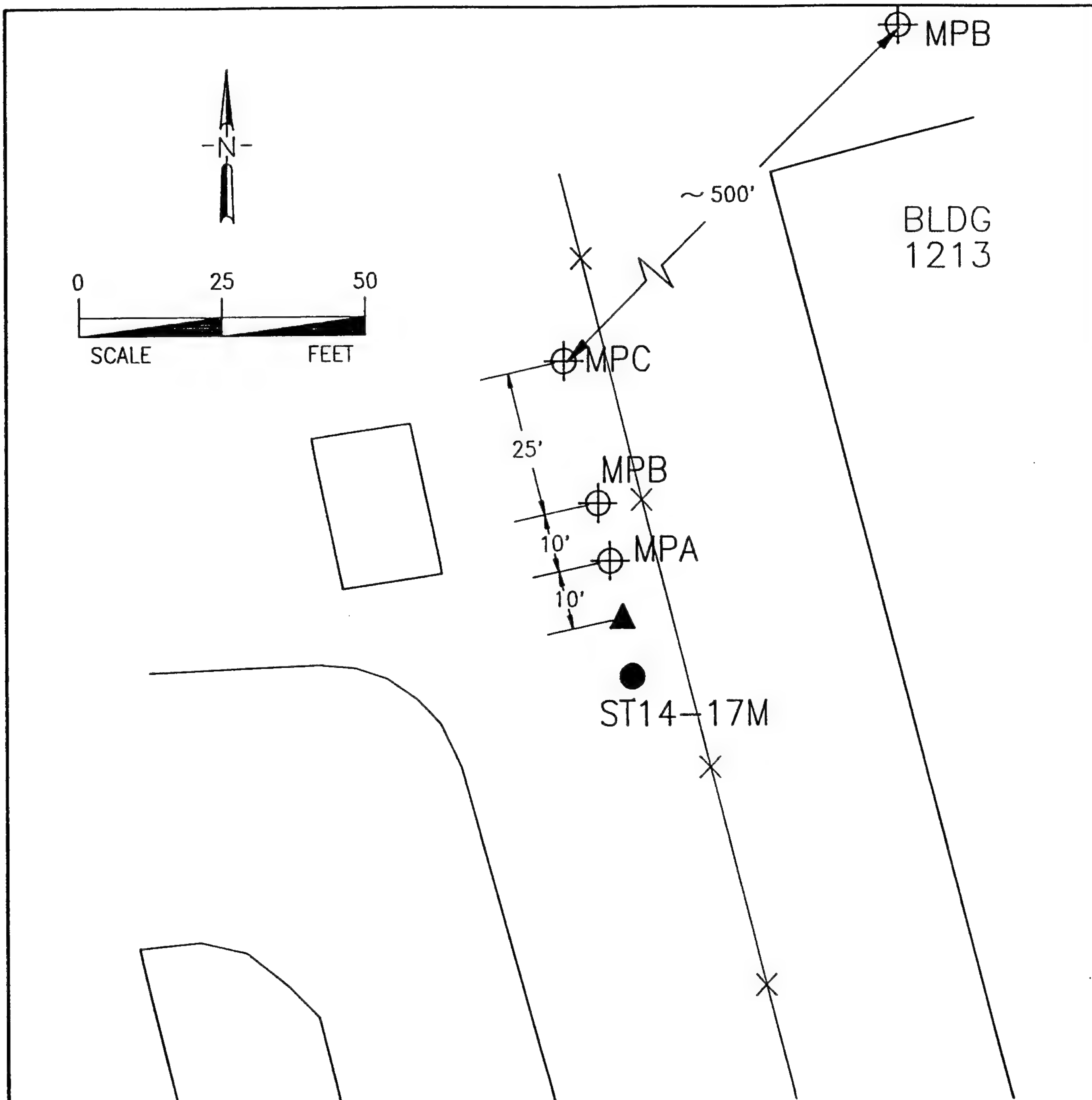

LEGEND

▲ PROPOSED CENTRAL VENT WELL (AIR INJECTION)

● ST14-17M EXISTING MONITORING WELLS

⊕ MPC PROPOSED VAPOR MONITORING POINT

—x—x— FENCE

1213 BUILDING

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SUBMITTED BY:
J.D. HIGHLAND

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FIGURE 2
AS-BUILT SITE PLAN
PILOT TEST SYSTEM

SITE ST14

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increasing in sand content as depth in the borehole increased. Saturated sand, with trace clay and gravel, was found at 11 feet below ground level (bgl). The static water level rose to 8.5 feet bgl during VW completion.

Monitoring Points

The three vapor MPs (MPA, MPB, and MPC), and the background MP (MPBG2) were constructed as shown in Figure 3. The MP screens were installed at 4.0-, 7.0-, and 10.0-foot depths. The construction details are discussed in appendix B and section 4 of this report. The 10.0-foot interval was saturated in each MP; and in MPB the 7-foot interval was also saturated. It was not possible to collect any data from these flooded screened intervals during air testing of the pilot system. These MPs were constructed at 10-foot depths so future measurements can be made if the static water level drops during seasonal fluctuations.

In Situ Respiration Test

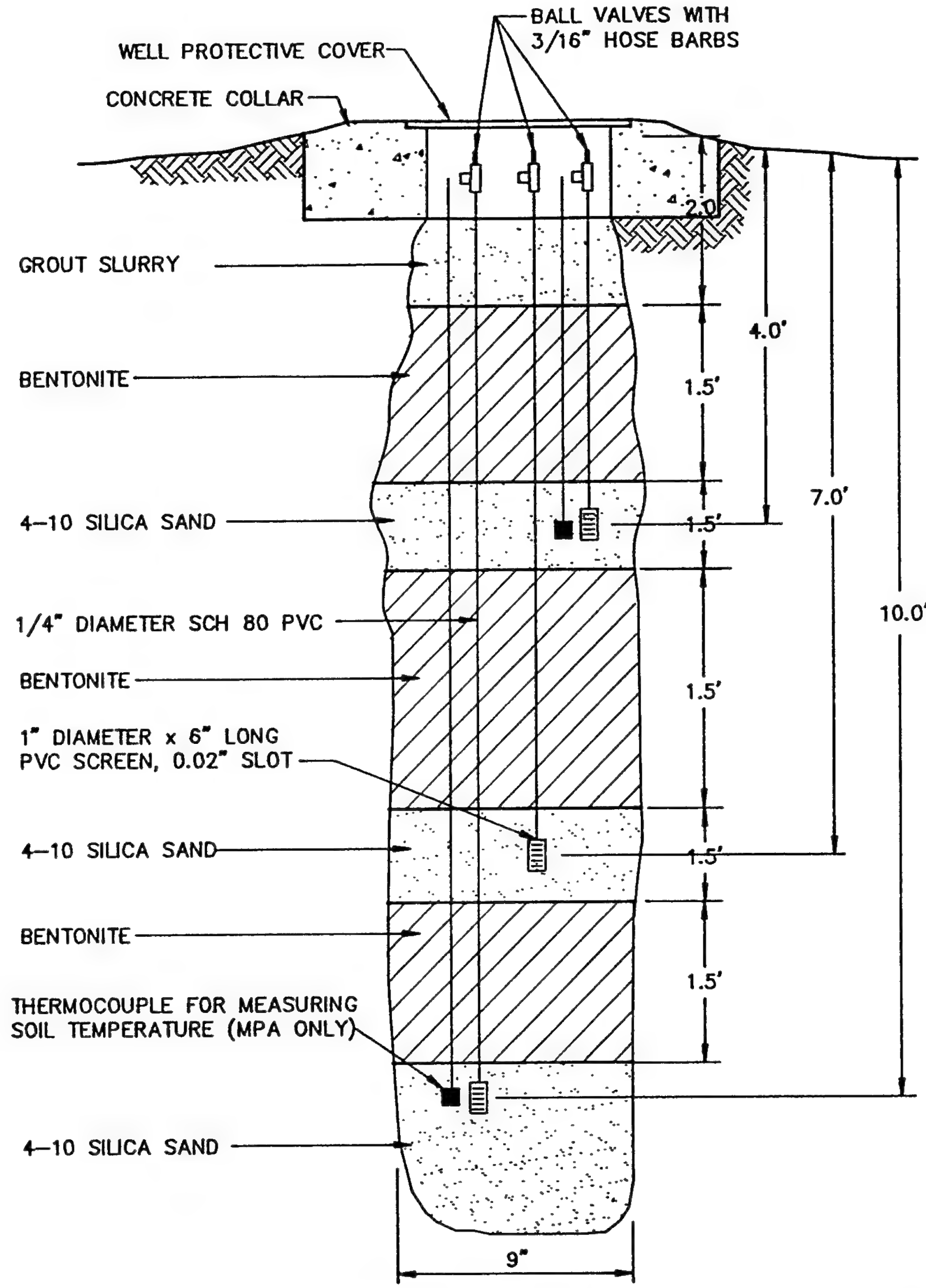
During the pilot test, several different types of blowers or pumps were employed for the respiration testing and the air permeability testing. Initial soil gas measurements were made before performing any other tests on the MPs using a 1-cubic feet per minute (cfm) vacuum pump (Gast™ 0211-1103A-G8CX) to purge several casing volumes from the monitoring points. A 12-minute purge was used for the vent well, and a minimum purge time of 2 minutes was used for the vapor MPs. Air samples were collected after purging in accordance with the protocol document (Hinchee et al., 1992). The results are discussed more fully in appendix B and section 3.

Based on oxygen, carbon dioxide, and field volatile hydrocarbon measurements, respiration tests were set up on the vent well and four MP depth intervals (MPA-4, MPA-7, MPB-4, and MPC-7). The MP depth intervals were chosen for respiration tests so at least two oxygen-deficient points were tested and to ensure a representative areal distribution.

A 1-cfm vacuum pump was used to inject air into the selected MP depth intervals for 16 hours. At the end of the 16-hour injection period, the air supply was cut off, and oxygen, carbon dioxide, and hydrocarbon levels were monitored for the following 24 hours. The decline in oxygen over time was used to estimate rates of bacterial degradation of fuel residuals. These results are summarized in section 3. Helium was also injected at each MP (at approximately 3 percent mixture with air) to account for oxygen loss by diffusion or leakage. Helium results are summarized in section 3 and described more fully in appendix B.

Air Permeability Test

An air permeability test was conducted using a portable 3 horsepower Roots™ 22U-RAI positive displacement blower unit at site ST14 according to protocol document procedures. Air was injected into the VW for approximately 3.5 hours at a rate of approximately 28 actual cubic feet per minute (acfm) and an average pressure of approximately 7 pounds per square inch (psi). The pressure response at each MP is summarized in section 3. The pressure measured at all MPs achieved



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DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624–93–08030 FY:93
DRAWN BY:	FIGURE 3
REVIEWED BY: B.R. VANDERGLAS	AS–BUILT MONITORING POINT CONSTRUCTION DETAIL PILOT TEST SYSTEM SITE ST14
SUBMITTED BY: J.D. HIGHLAND	
PLOT SCALE: NTS	DWG. CODE:
CONTRACT DATE: APRIL 30, 1992	SHEET REFERENCE NUMBER 3
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PLOT DATE: 8/10/93	SHEET 1 OF 1
CONTRACT NO.: F41624–92–D–8036	

steady-state conditions within 45 minutes. As discussed in the technical protocol document (Hinchee et al., 1992), two depths from both MPA (10 feet from injection point, VW1) and MPC (45 feet from injection point, VW1) were used to calculate relative air permeability of the soils. No response was observed in the 4-foot interval of MPB (20 feet from injection point, VW1). This may be due to the moist, highly plastic, and tightly consolidated clayey soils in which the monitoring point was constructed.

Oxygen Influence Testing

The depth and radius of oxygen influence in the subsurface soils resulting from air injection into the central VW during pilot testing constitute the primary design parameter for full-scale bioventing systems. Several soil gas measurements were made following different air injection periods and flow rate intensities to assess the radius of soil which can be oxygenated by the pilot system. Soil gas oxygen levels were measured after the 3.5-hour air injection test (28 acfm), and after the lower flow rate (24 acfm) air injection period, which extended for an additional 17 hours. Soil gas measurements were also taken after running the long-term pilot test blower for 15 hours. The air injection flow rate for this blower is approximately 15 acfm. The results of the oxygen influence testing are discussed in section 3.

Soil and Soil Gas Sampling

Soil samples for laboratory analysis were collected continuously using split-core barrel samplers. Soil samples were screened for volatile organic compounds (VOCs) using a total hydrocarbons analyzer (Porta FID II model PFII/7788 from Heathtech) to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected from MPA and MPB at depths of 9 to 10 feet bgl, from the VW at depths of 5 to 6 feet, and 10 to 11 feet, from MPC at depths of 6 to 7 feet, and from background monitoring point (MPBG2) at 10 to 10.5 feet.

Soil gas samples were collected after initial soil gas measurements were made from the completed VW and at 4 feet bgl from MPA, and at 7 feet bgl at MPC. Soil gas samples were collected using 3-liter Tedlar™ bags and vacuum chambers. After the samples were collected, they were transferred to 1-liter SUMMA™ canisters.

Soil samples were picked up every other day by a courier representing NDRC Laboratories. NDRC Laboratories conducted chemical and physical analyses on the soil samples. One soil sample from each boring was analyzed for total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethyl benzene and xylenes (BTEX); alkalinity; total Kjeldahl nitrogen (TKN); and several physical parameters. In boreholes in which two samples were collected (MPC and VW1), the sample collected nearest the surface was analyzed only for TRPH and BTEX. Soil gas samples were shipped via Federal Express to Air Toxics Ltd. in Rancho Cordova, California, for total volatile hydrocarbon (TVH) and BTEX analysis. The results of all of these analyses are discussed in section 3 and appendices B and C of this report.

Installation of 1-Year Pilot Test Bioventing System

The decision to proceed with bioventing was made after completion of the soil gas permeability and *in situ* respiration tests. Sufficient evidence exists to indicate that the addition of oxygen will enhance biodegradation in the contaminated areas at the POL tank farm area (site ST14). The pilot blower system was chosen based on the results of the initial respiration and air permeability tests. This long-term blower is capable of injecting air at 2 psi and 20 cfm, operating at 1.0 horsepower. The blower has vacuum, pressure, and temperature gauges, an air filter, and pressure relief and flow control valves. The as-built design is presented in section 4. The blower is housed in a small, prefabricated shed to provide protection from the weather. A licensed electrician subcontracted to ES assisted in wiring the blowers to line power. The system will be operated for up to 1 year; *in situ* respiration tests after 6 months and at the conclusion of the pilot test (1 year) to monitor the long-term performance of this bioventing system are recommended. Periodic system checks are currently being performed by Carswell AFB personnel. Detailed blower system information and a maintenance schedule are included in the draft operation and maintenance (O&M) manual provided to the base upon completion of field activities. More detailed information regarding the long-term pilot test procedures can be found in the protocol document.

SOILS INVESTIGATION ACTIVITIES

The purpose of this section is to summarize the work that was performed by Engineering-Science at ST14 following the bioventing pilot test to characterize the contamination in the fuel loading area of the POL. The characterization was completed such that vent wells were constructed in soil borings exhibiting significant contamination for eventual use in a full-scale bioventing system for the site. The primary activities performed during the site characterization were obtaining utility clearances and digging permits, decontamination of equipment, drilling with continuous lithologic sampling, and sample collection for analytical testing.

Preliminaries

Prior to any drilling, Engineering-Science met with utility representatives at the site to discuss concerns regarding buried utilities. The primary utilities in the investigation area are buried fuel lines which run to the west of the proposed pilot system, and buried electrical lines which run between line poles along the fence east of the pilot system. As a result of these discussions, the central VW and MP locations were moved to the east a few feet from the proposed location as a precautionary measure.

Once the pilot testing was completed, a radius of influence (ROI) for the additional vent wells and soil borings was determined to be approximately 60 feet. This ROI is based on the linear pressure curve between steady-state pressure readings achieved during the air permeability test in MPA at 10 feet from the vent well and MPC at 45 feet from the VW. The plotted pressure curves are discussed in section 3. The ROI was established during the test as the distance that receives pressure of at least ½ inch of water. Based on the ROI determination, adequate

VW borehole spacing of 90 to 100 feet should be sufficient to achieve coverage of the entire fuel loading area. A distance of 75 to 80 feet between boreholes was selected to provide conservative overlap for the full-scale system. Thirty-two stakes were placed in a grid pattern for maximum efficiency in the site characterization and full-scale bioventing system. A second digging permit and utility clearances were obtained for these boreholes before any drilling was initiated outside of the area already approved. Including the central VW, a total of sixteen VWs, four MPs, and seven soil borings were completed at the site. The approximate locations and type of completion at each borehole are shown in Figure 4. No borehole was drilled in the area between VW14 and VW15 because of a rather large network of buried fuel lines crisscrossing the site near the staked location.

Decontamination

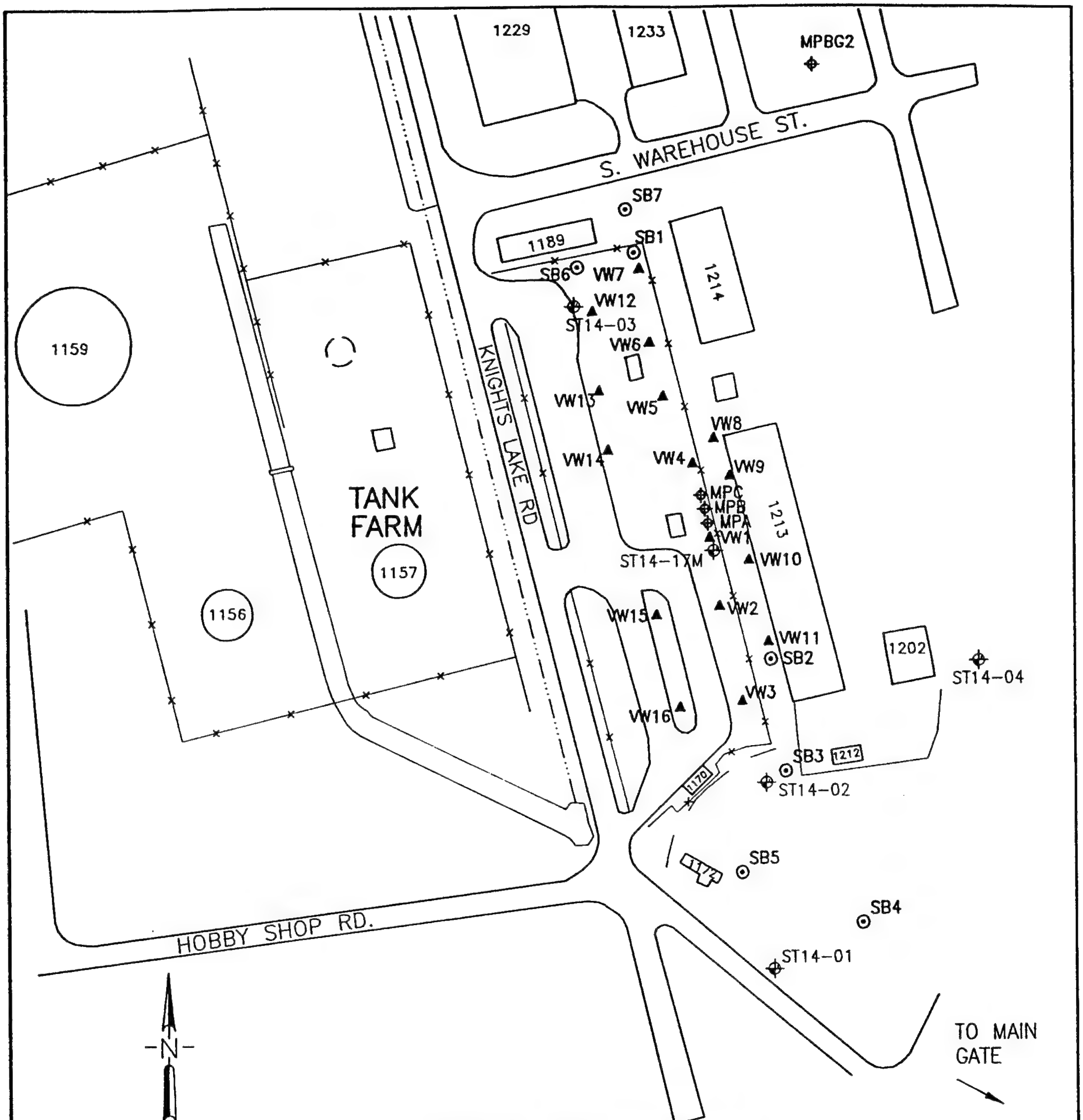
To ensure that no contamination was inadvertently introduced into a boring or vent well, all drilling, downhole, and sampling equipment was decontaminated between boreholes. Decontamination procedures consisted of a high-pressure steam cleaning in the decontamination pad area established south of the site. All sampling tools (i.e. split spoons and split-core barrels) were washed with soap and a brush and rinsed with distilled water before being placed into a borehole. Decontamination fluids were collected in the decontamination pad and transferred into 55-gallon drums for temporary disposal. Final disposition will occur after the fluids have been characterized for disposal.

Drilling

Soil borings were drilled at twenty-seven locations at the site. These borings were drilled for characterization sampling, vent well construction, and monitoring point construction.

Different borehole depths were required for each type of completion. The borings for characterization sampling (SB1 through SB7) were drilled to 13.5 feet bgl; the borings for VW construction were drilled from 16.5 to 18 feet bgl; and the depths of borings for MP construction ranged from 11 to 12 feet bgl. The boreholes were drilled using 8-inch-outer-diameter (OD), continuous-flight, hollow-stem augers. Soil samples were collected continuously using a split spoon or core barrel. The lithology of each sample was described in the field logbook. Lithologic logs of soil borings are in appendix D. Lithologic logs with well completion data for the sixteen VWs is also in appendix D.

The core samples were screened with an flame ionization detector (FID), and at least one sample per boring was placed into a jar for headspace analysis. If significant contamination was detected based on headspace readings or saturated visual characteristics, then a vent well was completed in the borehole for use in the full-scale bioventing system. Vent wells were constructed in each of the borings which exhibited characteristics of significant contamination (i.e., high headspace readings, oily saturated soil, heavy odors) except for SB1, SB2, and SB3. SB1 was originally intended to be the background MP (MPBG1), but when significant contamination was encountered, the background MP had to be moved and SB1 was properly abandoned. VW7 was constructed adjacent to SB1. SB2 was not originally



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SCALE FEET

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Symbol	Description
ST14-02	EXISTING MONITORING WELL
VW1	APPROXIMATE VENT WELL LOCATION
MPA	VAPOR MONITORING POINT
SB4	SOIL BORING LOCATION
—×—×—	FENCE
1172	BUILDING

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B.R. VANDERGLAS

SUBMITTED BY:
J.D. HIGHLAND

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FIGURE 4
APPROXIMATE BOREHOLE LOCATIONS AND TYPE OF COMPLETION
SITE ST14

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completed as a VW because VW materials were not available at the time of drilling. After receipt of VW construction materials, a new borehole was drilled 5 feet from SB2, and VW11 was constructed. No VW was constructed in SB3 because all VW construction materials were exhausted.

Sample Collection

Soil samples were collected continuously using split core barrel samplers. Once the samples were retrieved from the augers, the soils were screened for VOCs using the flame ionization detector to determine the presence of contamination and to select sampling intervals from the soil cores. The samples were also visually inspected, and odors were noted on the boring logs to assist in selection of the appropriate sampling depth. A portion of most split-core barrel samples was placed in a Mason jar and covered with foil for headspace analysis.

A maximum of two samples were collected from each boring. One sample was collected from each boring at just above water (about 10 to 11 feet below ground level) where the apparent highest levels of contamination were observed. A second sample was collected from six borings (MPC, VW1, VS3, VW5, SB2, and SB4) at other zones which exhibited signs of contamination based on the screening results, but from shallower portions of the screened interval of vent wells (5 to 8 feet bgl). A total of thirty-four samples were collected, including two duplicate samples for quality control.

The samples were placed into 8-ounce glass jars with Teflon-lined lids immediately after screening the soil core. The sample bottles were labeled and packed into an ice-cooled cooler before performing additional screening of the core or collecting additional samples. The sample identification references the borehole identifier (from Figure 4) and the interval which the sample was collected. For example, sample MPA:9-10 indicates a sample collected at 9 to 10 feet bgl from the borehole drilled for MPA completion.

Soil samples were picked up every other day by a courier representing NDRC Laboratories. NDRC Laboratories conducted chemical and physical analyses on the soil samples. At a minimum, each sample was analyzed for total recoverable petroleum hydrocarbons, benzene, toluene, ethyl benzene, and total xylenes. Analyses that are important in determining the baseline physical and nutrient characteristics of soils associated with each vent well were performed on one sample from the screened interval of each vent well. These analyses included alkalinity, total Kjeldahl nitrogen, phosphorus, pH, soil moisture, and particle size analysis. One sample from each MP was also analyzed for these parameters. None of the samples collected from soil borings were analyzed for these parameters since their function was primarily to characterize contamination at the site. The results of these analyses are discussed in section 3. The data sheets are in appendix C.

SECTION 3

INVESTIGATION RESULTS AND CONCLUSIONS

PILOT TEST RESULTS

The purpose of this section is to summarize the results of the pilot testing performed at site ST14. These results are more completely described in the results section of appendix B. The results of soil and gas sampling performed to support the pilot test, initial soil gas chemistry, *in situ* respiration testing, air permeability, and oxygen influence testing are discussed below.

Soil and Soil Gas Sampling Results

Soils at this site consist primarily of highly plastic clays with some interbedded gravel and silt near the surface. Sand content in soils generally increases with depth at the site, and soils are predominantly sands and gravels at approximately 11.5 to 12 feet and below. Groundwater was encountered at a depth of approximately 11.5 feet bgl in the VW, but the static water level rose to approximately 8.5 feet bgl in the open borehole. A thin film of oily product was observed on top of the water table in all the boreholes for VW1, MPA, MPB, and MPC. No evidence of contamination was observed in MPBG2, which was constructed as a background monitoring point. More detailed hydrogeologic information regarding site ST14 can be found in appendices B and D.

Contaminated soils were identified based on visual appearance, odor, and results of total hydrocarbons analyzer (Porta FID II, model PFII/7788 from Heathtech) field screening for volatile organic compounds. Heavily contaminated soils were encountered approximately 3 to 12 feet bgl in the VW and all MP boreholes. Contamination concentrations generally increased with depth.

Soil samples for laboratory analysis were collected from MPA and MPB at depths of 9 to 10 feet bgl, from the VW at depths of 5 to 6 feet, and 10 to 11 feet, from MPC at depths of 6 to 7 feet, and from background monitoring point MPBG2 at 10 to 10.5 feet. Soil gas samples were collected from the completed VW and at 4 feet bgl from MPA, and at 7 feet bgl at MPC. The results of all of these analyses are in Table 1.

The results indicate that significant fuel contaimination is present in the test area around the central VW (VW1). Low concentrations of TRPH were detected in the MPBG2 (background MP), but the levels are not so significant as to preclude using MPBG2 to provide baseline data for the test system. None of the physical

Table 1. Site ST14; Pilot Test Sampling
Soil and Gas Analytical Results
Carswell AFB, Texas

	Sample Location - Depth (feet below ground surface)							
Analyte (units)*	VW1:10-11	VW1:5-6	MPA:9-10	MPB:9-10	MPC:6-7	MPC:10-11	MPBG2:10	MPA:4
Soil hydrocarbons:								
TRPH (mg/kg)	1,500	890	2,500	2,500	1,100	1,500	47	NT
Benzene (mg/kg)	.27	0.41	1.8	2.8	<.5	<0.2	<.002	NT
Toluene (mg/kg)	.53	0.58	3.7	4.1	2	10	<.002	NT
Ethyl benzene (mg/kg)	1.40	0.79	5.3	7	3.7	2.6	<.002	NT
Xylenes (mg/kg)	8.80	4.20	36	26	24	17	<.002	NT
Soil gas hydrocarbons:								
TVH (ppmv)	NT**	23,000	NT	NT	28,000	NT	NT	21,000
Benzene (ppmv)	NT	ND†	NT	NT	ND	NT	NT	ND
Toluene (ppmv)	NT	ND	NT	NT	ND	NT	NT	ND
Ethyl benzene (ppmv)	NT	6.4	NT	NT	7.9	NT	NT	4.4
Xylenes (ppmv)	NT	19	NT	NT	21	NT	NT	11.0
Soil inorganics:								
Phosphorus (mg/kg)	97.2	NT	114	96.2	NT	73.1	85.8	NT
Alkalinity (mg/kg as $CaCo_3$)	350	NT	350	450	NT	250	1,550	NT
TKN (mg/kg)	350	NT	280	224	NT	420	238	NT
Soil physical parameters:								
Moisture (% wt)	15.3	NT	25.3	23	NT	16.3	15.7	NT
pH (units)	8.9	NT	8.6	9	NT	8.9	8.3	NT
Gravel (% >2.0 mm)	<0.1	NT	<0.1	<0.1	NT	<0.1	<0.1	NT
Sand (% 0.75-2.0 mm)	20.5	NT	7.5	6	NT	38.6	24.5	NT
Silt (% .05-0.75 mm)	60.6	NT	65.8	60.4	NT	49.5	57	NT
Clay (% <0.005 mm)	18.9	NT	26.8	33.6	NT	11.9	18.5	NT
Soil temperature, 6-9-93 (°F)	NT	NT	64.3	NT	NT	NT	NT	69.8
Soil temperature, 6-15-93 (°F)	NT	NT	64.9	NT	NT	NT	NT	72.8

* TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram; TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen; °F = degrees Fahrenheit.

** NT = not tested at this location.

† ND = not detected.

320SR\AU380\TABLE1

characteristics appear to be limiting. The temperature, pH, and alkalinity of the soils are near normal for optimal microbial biodegradation of the hydrocarbons. Sufficient nutrient levels also appear to be present. Although the moisture content seems to be somewhat high, the estimated air-filled porosites of 6 to 11 percent were sufficient to allow air exchange and movement through the soil profile.

Initial Soil Gas Chemistry

Table 2 summarizes the initial soil gas chemistry at site ST14. The results strongly indicate that biological fuel degradation has depleted the oxygen supply in the vadose zone soils. Three of the six sampling points at site ST14 were under anaerobic conditions, and soil gas at the remaining three sampling points contained oxygen at low levels ranging from 0.8 percent to 3.8 percent. In contrast, the background MP, installed in uncontaminated soil approximately 500 feet northeast of the site, contained oxygen at levels ranging from 13.2 percent (7-foot depth) to 20.6 percent (4-foot depth). Carbon dioxide was present at elevated concentrations in all MPs, ranging from 9.0 to 11.0 percent, in all initial soil gas samples collected at site ST14. The ambient oxygen and carbon dioxide levels of MPBG2 at 4 feet bgl suggest that short-circuiting between this interval and the surface has occurred, which indicates an inadequate seal between the surface and this MP depth. High hydrocarbon concentrations measured in the initial soil gas testing possibly indicate the volatilization of fuel from the free product layer into the pore space of the vadose zone soils at site ST14.

In Situ Respiration Testing Results

Calculations based on pilot test results indicate that, at site ST14, an estimated 2,555 to 16,790 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year. These values were calculated as described in the protocol document (Hinchee et al., 1992). Table 3 lists the oxygen utilization rates and key assumptions used to calculate the degradation rate at each point. Moisture contents were used based on a single data point from each MP and may not be indicative of the actual moisture content in the interval which underwent utilization testing. This is important to note since an increase in actual moisture content of the soils results in a decrease in the actual degradation rate of the hydrocarbons, as calculated. The air-filled porosities calculated for each sampling point ranged from 0.06 to 0.15 liters of air per kilogram of soil. Point-specific fuel consumption rates were calculated using observed oxygen utilization rates, estimated air-filled porosities, and a conservative ratio of 3.5 milligrams of oxygen consumed for every 1 milligram of fuel biodegraded. The calculated values are different than those in the pilot test results report (appendix B) because different assumptions were used. Oxygen loss was rapid and linear at every sampling point during approximately the initial 500 minutes of the *in situ* respiration test. The oxygen utilization rates observed at site ST14 ranged from 0.016 percent per minute (%/min) to 0.045 %/min (Table 3), demonstrating that hydrocarbon contamination is spread uniformly through the pilot test area.

Table 2. Site ST14; Initial Soil Gas Chemistry
Carswell AFB, Texas

MP	Depth	O_2(%)	CO_2(%)	Field TVH* (ppmv)	Lab TVH (ppmv)	Lab TRPH (mg/kg)
VW	5-8.5	3.8	10.1	294,000	23,000	890
A	4	0.8	10.4	546,000	21,000	NT**
A	7	0.0	10.8	<200,000	NT	NT
A	10	NS†	NS	NS	NS	2,500
B	4	0.0	11.0	290,000	NT	NT
B	7	NS	NS	NS	NT	NT
B	10	NS	NS	NS	NS	2,500
C	4	0.0	10.3	200,000	NT	NT
C	7	2.2	9.8	212,000	28,000	1,100
C	10	NS	NS	NS	NS	1,500
BG2	4	20.6	0.05	NT	NT	
BG2	7	13.2	9.0	NT	NT	
BG2	10	NS	NS	NS	NS	

* Estimated value using dilution method.
** NT = not tested at this location.
† NS = not sampled because of saturated moisture conditions at MP depth interval.

320SR\AU380\TABLE2

Table 3. Site ST14;
Factors and Calculated Values for Important Parameters in Biodegradation Calculations, Carswell AFB, Texas

MP	Utilization Rate % min	Utilization Rate % day	Moisture Content (%)	Air-Filled Volume (%)	Liters Of Air Per kilogram of soil	Degradation Rate (mg/kg soil/year)
VW	0.045	64.80	15.3	23	0.15	13,468
MPA-4	0.016	23.04	25.3	8	0.06	2,555
MPA-7	0.040	57.60	25.3	8	0.06	6,391
MPB-4	0.025	36.00	23.0	12	0.08	5,986
MPC-7	0.040	57.60	16.3	21	0.14	16,790

*Equation for biodegradation rate calculation:

$$K_B = Ko\ A\ Do\ C/100$$

where:

K_B = biodegradation rate (mg/kg per day)
Ko = oxygen utlization rate (percent per day)
A = volume of air per kilogram of soil (l/kg)
Do = density of oxygen gas (mg/l)
C = mass ratio of hydrocarbon to oxygen required for mineralization

Key assumptions:

1. Oxygen utilization rates based on linear regressions of data at each point
2. Bulk density of soils is 1.45 kg/liter, porosity = 45%
3. Density of oxygen = 1,330 mg/liter
4. C = 1/3.15, based on hexane

320SR\AU380\TABLE3

Air Permeability Test Results

The pressure response at each MP is listed in Table 4. Pressure measured at all MPs achieved steady-state conditions within 45 minutes. Since more than 10 minutes was required to achieve steady state in all of the monitoring points, the dynamic method of determining soil gas permeability was selected. As discussed in the technical protocol document (Hinchee et al., 1992), the dynamic method of determining soil gas permeability that is coded in the HyperVentilate™ model is appropriate for soils which reach steady state in more than approximately 10 minutes. Two depths from both MPA (10 feet from injection point, VW1) and MPC (45 feet from injection point, VW1) were used to calculate relative air permeability of the soils. Negative responses were observed in the 4-foot interval of MPB (20 feet from injection point, VW1). This may be due to the moist, highly plastic, and tightly consolidated clayey soils in which the monitoring point was constructed.

A constant injection flow rate of 28 afcm and a screened interval thickness of 3.5 feet (5 feet bgl top of screen to 8.5 feet bgl to water level in vent well) were used to calculate soil gas permeabilities of 26.4 and 30.8 darcy for the 10-foot radial distance at 4 and 7 feet, respectively. Soil gas permeabilities for the 45-foot radial distance at 4 and 7 feet are 94.2 and 93.4 darcy, respectively. An average of 61.2 darcy was calculated for this site. This value is approximately one order of magnitude higher than would be expected for the predominantly clayey soils at the site; however, the presence of gravel throughout the soil profile and increasing sand content with depth appears to have increased the average permeability at this site. A radius of pressure influence of at least 45 feet was observed at all depths. Given the steady-state pressure responses from 10 and 45 feet from the vent well, and assuming a linear relationship, the estimated radius of influence for this site at 28 acfm appears to be 60 feet. Figure 5 depicts the steady state responses of monitoring points measured during air permeability testing and after running the long-term, lower flow, blower for 12 hours.

Oxygen Influence Results

Table 5 describes the change in soil gas oxygen levels that occurred during the 3.5-hour air injection test at the site, and the air injection period which extended at a lower flow rate (24 acfm) for an additional 17 hours. The relatively brief air injection period (3.5 hours) at 28 acfm produced changes in soil gas oxygen levels at a distance of at least 45 feet from the central VW at both monitored depth intervals in MPA and MPC and at the one monitored depth interval in MPB. Significant increases in the oxygen concentration were measured at each MP interval. Considering measured pressure response, which is an indicator of long-term oxygen transport, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 45 feet at all depths. Monitoring during the extended pilot test at this site will better define the effective treatment radius. Oxygen increases in MPC after installing and running the long-term blower for 12 hours at only 15 acfm also indicate that the long-term blower selected will be able to deliver oxygen to the contaminated soils at least 45 feet from the VW.

Table 4. Site ST14; Pressure Response During the Air Permeability Test, Carswell AFB, Texas

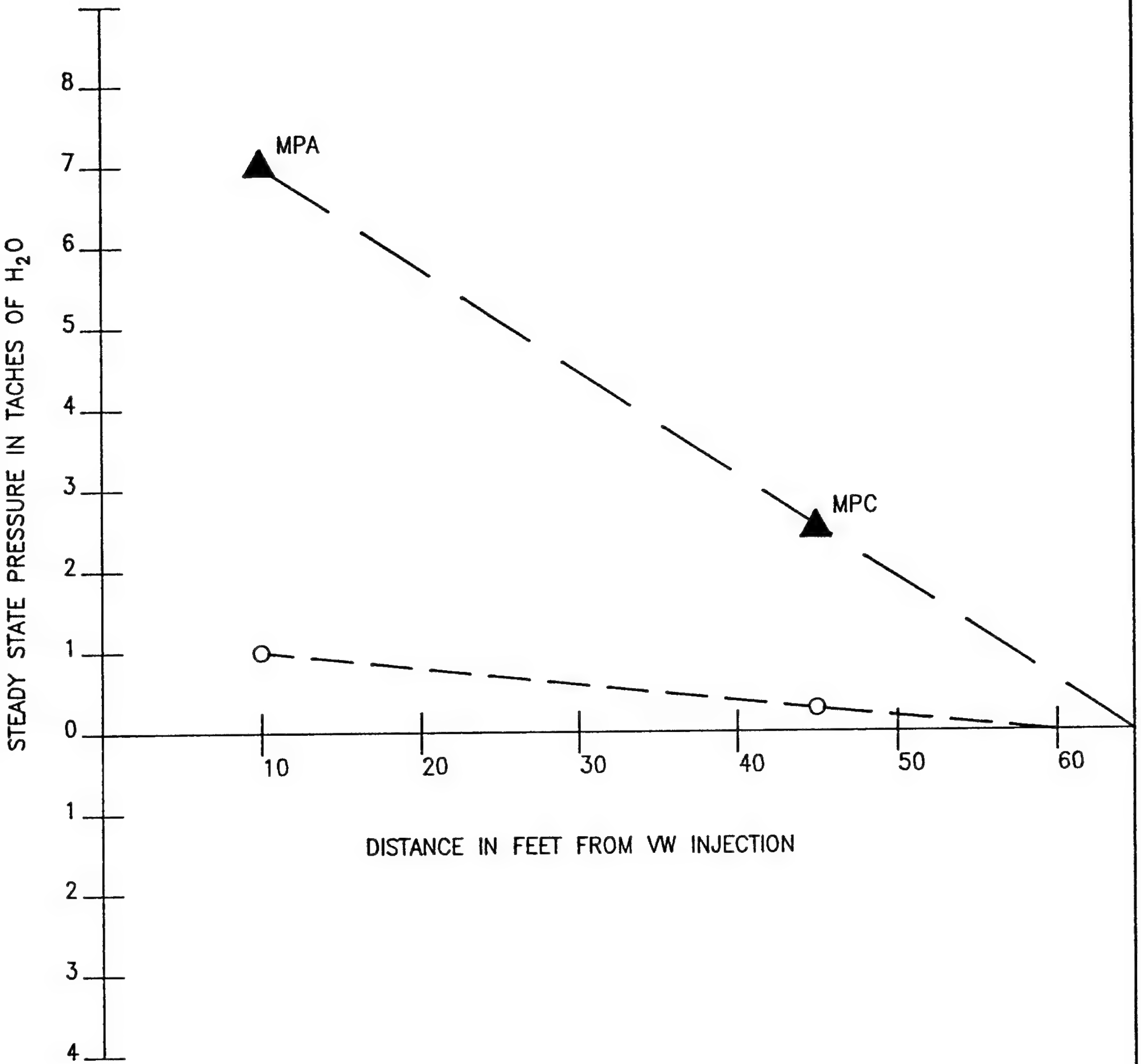
Elapsed Time (min)	Location: Depth (ft):	Pressure Response in MP (inches of water)				
		MPA		MPB	MPC	
		4	7	4	4	7
0*		-0.05**	0.00	-0.10	0.20	0.20
0.5		0.00	0.85	-0.30	0.15	0.20
1.0		0.10	2.20	-0.30	0.15	0.20
2.0		0.45	3.50	-0.35	0.30	0.25
3.0		0.75	4.55	-0.35	0.20	0.25
4.0		1.00	6.00	-0.40	0.55	0.35
5.0		1.40	7.20	-0.50	0.80	0.70
6.0		2.30	8.40	-0.50	1.05	1.10
7.0		--†	--	-0.50	1.40	1.35
8.0		2.75	9.40	--	1.70	1.70
9.0		--	--	--	2.10	2.10
10.0		3.90	>10.00	--	2.25	2.25
12.0		4.85	11.00	0.00	2.65	2.60
22.0		8.00	11.70	-0.30	3.10	3.05
37.0		9.70	12.20	-0.40	3.50	3.50
54.0		11.70	12.80	--	--	--
92.0		12.20	13.00	+0.25	3.60	3.60
120.0		12.10	13.10	+0.25	3.60	3.65
152.0		12.10	13.10	+0.40	3.60	3.65

* Pressure readings taken prior to initiating field test (blower startup).

** Negative sign indicates vacuum pressure at MP.

† Denotes no reading taken at this time.

320SR\AU380\TABLE4



▲ MPA PERMEABILITY TEST RESULTS

○ STEADY STATE RESULTS OF OPERATING LONG TERM BLOWER

ENGINEERING–SCIENCE
DESIGN ◆ RESEARCH ◆ PLANNING
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Offices in Principal Cities

U.S. Air Force Center for Environmental Excellence

CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS
PN:FY7624–93–08030 FY:93

FIGURE 5
RADIUS OF INFLUENCE
PRESSURE vs. DISTANCE
DETERMINATION
SITE ST14

DESIGNED BY:

DRAWN BY:

REVIEWED BY: B.R. VANDERGLAS

SUBMITTED BY: J.D. HIGHLAND

PLOT SCALE: NTS

DWG. CODE:

CONTRACT DATE: APRIL 30,1992

CALL ORDER NO.: 0004

DESIGN FILE: RAD–INF

PLOT DATE: 8/11/93

SHEET OF

CONTRACT NO.: F41624–92–D–8036

SHEET REFERENCE NUMBER 5

Table 5. Site ST14;
Influence of Air Injection at Vent Well on Monitoring Point Oxygen Levels
Carswell AFB, Texas

MP	Distance from VW (ft)	Depth (ft)	Initial O_2 (%)	O_2 (%)	Test O_2 (%)	O_2 (%)^3
A	10.0	4	3.2	18.0	19.4	19.6
A	10.0	7	0.0	17.9	20.4	19.9
A	10.0	10	NS†	NS	NS	NS
B	20.0	4	0.0	12.3	17.7	13.6
B	20.0	7	NS	NS	NS	NS
B	20.0	10	NS	NS	NS	NS
C	45.0	4	0.0	1.3	11.1	1.8
C	45.0	7	0.0	2.0	12.7	2.8
C	45.0	10	NS	NS	NS	NS

1 Duration of air injection = 3.5 hours at 28 acfm
2 Duration of air injection = 3.5 hours at 28 acfm, and 17 hours at 24 acfm
3 Oxygen level measured after running longterm blower for 12 hours at 15 acfm
† NS = not sampled due to water levels extending into MP sampling interval

SOIL SAMPLING RESULTS

The purpose of this section is to summarize the results of investigation activities performed at site ST14 to characterize and delineate the extent of contamination at the site. The soils investigation was primarily designed to characterize the contamination and to delineate its probable extent in the unsaturated soils at site ST14. The secondary objective was to provide data on physical parameters and nutrients to determine if a full-scale system is suitable for the site. Borehole spacing was selected, based on the radius of influence identified in the pilot test, such that vent wells could be constructed in boreholes exhibiting significant contamination for eventual incorporation into a full-scale system for bioventing remediation at the site.

Contamination Characterization and Delineation

Thirty-four samples were collected at the site from twenty-seven soil boreholes and analyzed for TRPH and BTEX compounds. The locations of these boreholes and types of completions are shown on Figure 4. The results of the analysis are presented in Table 6.

The TRPH values were used to delineate the extent of contamination at the site for design of the full-scale bioventing system at the site. Figure 6 shows the highest TRPH levels detected in boreholes sampled during the characterization. The data indicate that contamination is spread uniformly across the site, with higher levels of contaminants centered around SB1, VW7, VW6, and VW12 on the north end of the site, and around VW2, VW3, VW11, and VW15 on the southern portion of the site. The northern fence of the fuel loading area is the approximate northern boundary of contamination, as evidenced by no contaminants found in SB7 and few contaminants found in SB6. No contaminants were found in either SB4 or SB5 outside the southern fence of the site, but data from SB3 suggest that significant contamination extends to the area around this point south of the fence. A vent well was not constructed in this borehole because not enough construction materials remained at the site for completion.

Data from SB2, VW10, VW9, and VW8 indicate significant contamination in these boreholes, which were drilled approximately 10 feet west of building 1213. This suggests that contamination extends beneath the building. No soils data from the east side of building 1213 exist to determine how far the contamination plume extends in the easterly direction. Also, no data are available from the area around building 1214, north of VW8, to assess the extent of contamination northeast of the site. Data from VW16, VW15, and VW13 indicate that contamination extends at least to the center of the fuel loading area. No additional data were collected along the western fence line, toward the tank farm, to determine the western extent of the contamination plume at site ST14, or to assess the potential for continuity between the fuel loading area and the tank farm across Knight's Lake Road.

The vent well grid pattern established provides coverage for the majority of contamination found at the site. The ROI of the operating vent wells along building 1213 will enable oxygen to be carried to the majority of the soils beneath the building. The northern boundary of the plume can receive oxygen from VW7

Table 6. Analytical Results: Site ST14
Carswell AFB, Texas

	VW1: 5-6	VW1: 10-11	VW2: 10-11	VW3: 7-8	VW3: 10-11	VW4: 10-11	VW5: 7-8	VW5: 10-11	VW6: 9-10
Parameter:									
Benzene ($\mu g/kg$)	410	270	<200	<2.0	1,000	160	<10	<10	950
Tolulene ($\mu g/kg$)	580	530	19,000	<2.0	12,000	570	380	440	310
Ethyl benzene ($\mu g/kg$)	790	1,400	5,200	<2.0	3,600	1,500	120	<10	980
Xylenes ($\mu g/kg$)	4,200	8,800	25,000	4.1	18,000	6,900	410	1,200	1,800
BTEX ($\mu g/kg$)	5,980	11,000	49,200	4.1	34,600	9,130	910	1,640	4,040
TRPH (mg/kg)	890	1,500	6,500	<10	4,500	1,900	420	2,600	3,800

	VW7: 9-10	VW8: 10-11	VW8:[1] Dup	VW9: 9-10	VW10: 10-11	VW12: 10-11	VW13: 9-10	VW14: 9-10	VW15 11-12
Parameter:									
Benzene (μkg)	<1,000	2,000	1,900	200	470	3,800	<2,000	890	<1,000
Tolulene (μkg)	19,000	2,600	3,400	3,600	740	2,600	54,000	2,900	10,000
Ethyl benzene (μkg)	3,600	1,200	1,300	910	1,100	2,700	17,000	1,500	3,400
Xylenes (μkg)	4,800	5,000	6,100	4,800	5,200	5,900	52,000	7,100	14,000
BTEX ($\mu g/kg$)	27,400	10,800	12,700	9,510	7,510	15,000	123,000	12,400	27,400
TRPH (mg/kg)	5,700	1,900	2,300	1,200	1,500	2,900	1,400	350	3,600

[1] VW8: Dup is a duplicate of VW8:10-11
[2] MPGB1: Also referred to as SB1
[3] VW11: VW11 drilled 5 feet north of SB2
[4] SB4: Dup is a duplicate of SB4:10-11

320SR\AU380\TABLE6

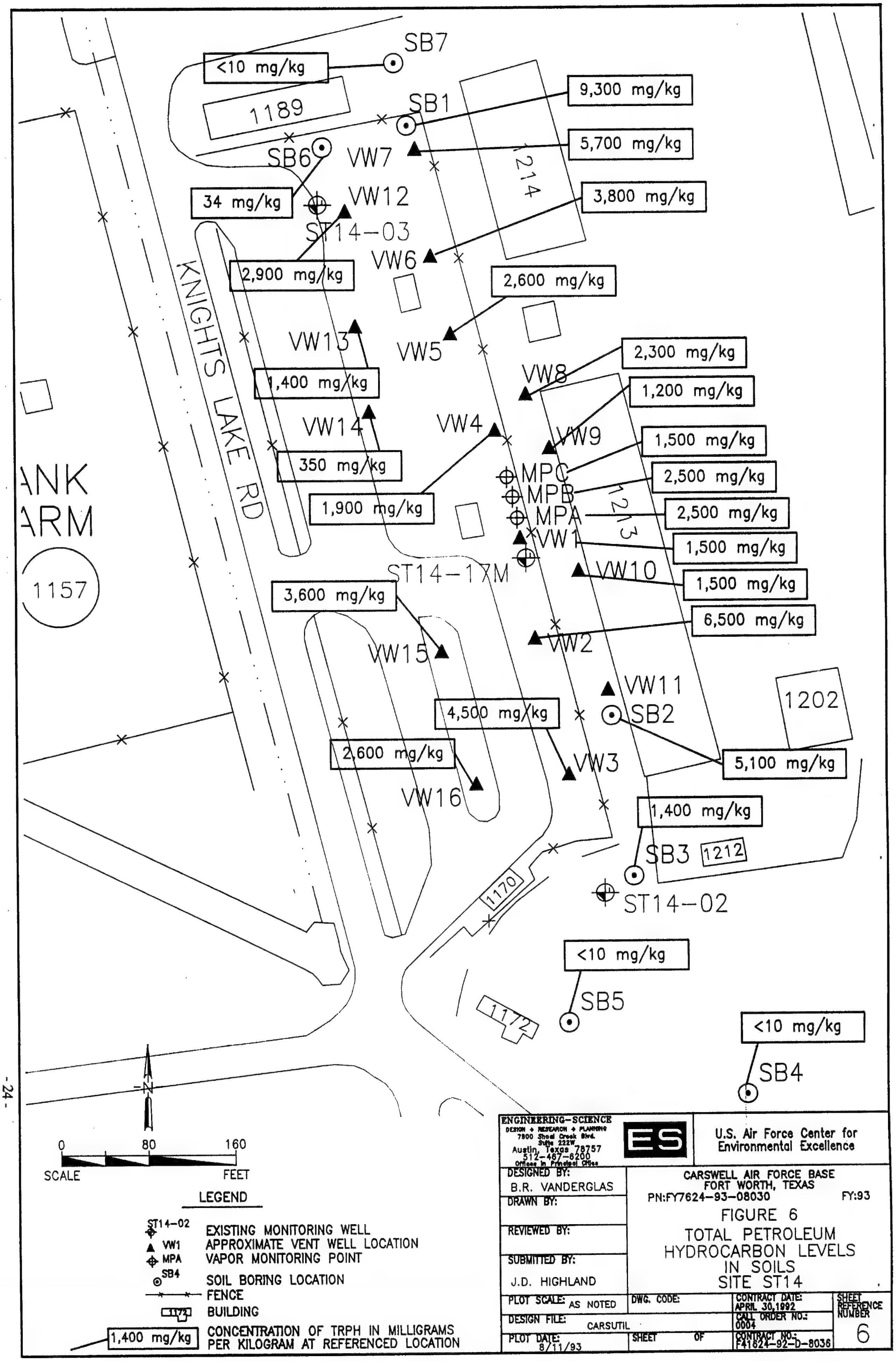
Table 6, continued

	VW16: 9-10	MPA: 9-10	MPB: 9-10	MPC: 6-7	MPC: 10-11	MPBG1: [2] 10-11	MPBG2: 10	SB2: [3] 7-8	SB2: 10-11
Parameter:									
Benzene ($\mu g/kg$)	2,800	1,800	2,800	<500	<200	67,000	<2.0	3.6	53
Tolulene ($\mu g/kg$)	11,000	3,700	4,100	2,000	10,000	<5,000	<2.0	4.8	600
Ethyl benzene ($\mu g/kg$)	6,600	5,300	7,000	3,700	2,600	14,000	<2.0	7.4	<10
Xylenes ($\mu g/kg$)	32,000	36,000	26,000	24,000	17,000	7,700	<2.0	40.0	2,000
BTEX (μ /kg)	52,400	46,800	39,900	29,700	29,600	88,700	<2.0	55.8	2,650
TRPH (mg/kg)	2,600	2,500	2,500	1,100	1,500	9,300	47	<10	5,100

	SB3: 9-10	SB4: 7-8	SB4: 10-11	SB4: [4] Dup	SB5: 10-11	SB6: 9-10	SB7: 11-12
Parameter:							
Benzene ($\mu g/kg$)	5,400	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Tolulene ($\mu g/kg$)	15,000	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ethyl benzene ($\mu g/kg$)	4,100	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Xylenes ($\mu g/kg$)	24,000	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
BTEX (μ /kg)	48,500	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
TRPH (mg/kg)	1,400	<10	<10	<10	<10	34	<10

[1] VW8: Dup is a duplicate of VW8:10-11
[2] MPGB1: Also referred to as SB1
[3] VW11: VW11 drilled 5 feet north of SB2
[4] SB4: Dup is a duplicate of SB4:10-11

320SR\AU380\TABLE6



SB7
<10 mg/kg
1189
SB1
9,300 mg/kg
5,700 mg/kg
SB6
VW7
1214
34 mg/kg
VW12
3,800 mg/kg
ST14-03
VW6
2,900 mg/kg
2,600 mg/kg
KNIGHTS LAKE RD
VW13
VW5
2,300 mg/kg
1,400 mg/kg
VW8
1,200 mg/kg
VW14
VW4
VW9
1,500 mg/kg
350 mg/kg
MPC
2,500 mg/kg
MPB
1,900 mg/kg
1213
MPA
2,500 mg/kg
VW1
1,500 mg/kg
1157
ST14-17M
VW10
1,500 mg/kg
3,600 mg/kg
6,500 mg/kg
VW2
VW15
VW11
1202
4,500 mg/kg
SB2
2,600 mg/kg
5,100 mg/kg
VW3
VW16
1,400 mg/kg
SB3
1212
1170
ST14-02
<10 mg/kg
SB5
1172
<10 mg/kg
SB4
N
0
80
160
SCALE
FEET
LEGEND
ST14-02 EXISTING MONITORING WELL
VW1 APPROXIMATE VENT WELL LOCATION
MPA VAPOR MONITORING POINT
SB4 SOIL BORING LOCATION
FENCE
1172 BUILDING
1,400 mg/kg CONCENTRATION OF TRPH IN MILLIGRAMS PER KILOGRAM AT REFERENCED LOCATION
ENGINEERING-SCIENCE
DESIGN • RESEARCH • PLANNING
7800 Shoal Creek Blvd.
Suite 222W
Austin, Texas 78757
512-467-6200
Offices in Principal Cities
ES
U.S. Air Force Center for Environmental Excellence
DESIGNED BY:
B.R. VANDERGLAS
DRAWN BY:
REVIEWED BY:
SUBMITTED BY:
J.D. HIGHLAND
CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS
PN:FY7624-93-08030
FY:93
FIGURE 6
TOTAL PETROLEUM HYDROCARBON LEVELS IN SOILS
SITE ST14
PLOT SCALE: AS NOTED
DWG. CODE:
CONTRACT DATE: APRIL 30,1992
SHEET REFERENCE NUMBER
6
DESIGN FILE: CARSUTIL
CALL ORDER NO.: 0004
PLOT DATE: 8/11/93
SHEET OF
CONTRACT NO.: F41624-92-D-8036

and VW12. The areas which may not be covered by existing VWs include a portion south of the fence line and possibly areas not fully characterized, such as the east side of building 1213 areas around building 1214, and along the western edge of the fuel loading area. Air injected into VW16, VW15, VW14, and VW13 should deliver minimal oxygen levels to soils near, but east of, Knight's Lake Road. A small gap may also exist between VW14 and VW15 because of the large number of buried fuel lines in that area which prevented construction of a vent well in the preferred location.

Soil Venting Characteristics

Except for VW11, at least one soil sample was collected from the screened interval of each VW and MP for analysis of soil venting parameters such as physical characteristics of soil and nutrient content. These data are important in determining the suitability of each VW. The results are shown in Table 7. Samples were not collected in VW11 because samples had already been collected in SB2 (5 feet south of VW11) for TRPH and BTEX analysis.

Based on the data from fifteen VWs and MPs sampled, none of the physical parameters or nutrients appear to limit the potential effectiveness of bioventing at site ST14. Moisture contents in the samples ranged from 8.2 percent in VW2 to 25.3 percent in MPA. The average moisture content was 17.3 percent. At these levels, there is still sufficient air-filled porosity to allow gaseous exchanges to occur in the unsaturated soil. The pH values ranged from 8.2 to 9.5, which are slightly higher than optimum, but should not be toxic to microbes. High pH values such as these can precipitate more stable forms of phosphorus, making phosphorus levels in soil less available. The initial reaction of the microbial population after stimulation with supplied oxygen suggests that oxygen was the only factor currently limiting the metabolic actions of the microbes in the unsaturated soils at the site.

Table 7. Soil Venting Characteristics: ST14, Carswell AFB, Texas

Sample Number	VW1: 10–11	MPA: 9–10	MPB: 9–10	MPC: 10–11	MPBG2: 10'	VW2: 10–11	VW3: 7–8	VW4: 10–11	VW5: 7–8	VW6: 9–10
Parameter:										
Gradation report										
Gravel and coarse sand (> 2.00 mm) (%)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Medium and fine sand (0.075 to 2.00 mm) (%)	20.5	7.5	6.0	38.6	24.5	37.9	9.7	13.9	17.6	66.2
Silt (0.005 to 0.075 mm) (%)	60.6	65.8	60.4	49.5	57.0	48.5	57.6	61.4	52.8	24.9
Clay/colloids (< 0.005 mm) (%)	18.9	26.8	33.6	11.9	18.5	13.6	32.7	24.7	29.6	8.9
Phosphorus (mg/kg)	97.2	114	96.2	73.1	85.8	62.4	133	89.0	211	81.4
Alkalinity (mg/kg CaCO3)	350	350	450	250	1550	206	412	515	515	464
Moisture (%)	15.3	25.3	23	16.3	15.7	8.2	12.7	15.0	18.8	15.4
Nitrogen, total Kjeldahl (mg/kg)	350	280	224	420	238	224	462	336	714	308
pH	8.9	8.6	9	8.9	8.3	8.6	8.2	8.4	8.5	8.6
Total solids (%)	84.7	74.7	76.9	83.7	84.3	91.8	87.3	85.0	81.2	84.6

Sample Number	VW7: 9–10	VW8: 9–10	VW8: dup	VW9: 9–10	VW10: 10–11	VW12: 10–11	VW13: 9–10	VW14: 9–10	VW15: 11–12	VW16: 9–10
Parameter:										
Gradation report										
Gravel and coarse sand (> 2.00 mm) (%)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Medium and fine sand (0.075 to 2.00 mm) (%)	52.1	9.9	9.5	13.8	6.8	31.8	81.0	4.6	49.3	55.4
Silt (0.005 to 0.075 mm) (%)	35.6	63.1	61.4	53.7	65.1	51.4	14.2	67.4	38.5	35.3
Clay/colloids (< 0.005 mm) (%)	12.3	27.0	29.1	32.5	28.1	16.9	4.8	28.0	12.1	9.3
Phosphorus (mg/kg)	67.7	96.6	97.7	98.4	88.3	76.9	73.5	90.9	118	105
Alkalinity (mg/kg CaCO3)	206	361	412	309	790	1310	1350	490	1260	1360
Moisture (%)	14.5	22.1	21.1	21.7	23.7	14.0	16.2	19.8	13.4	14.0
Nitrogen, total Kjeldahl (mg/kg)	420	504	378	392	294	280	140	350	252	280
pH	9.5	8.5	8.7	8.6	8.8	9.0	8.8	8.9	9.1	8.6
Total solids (%)	85.5	77.9	78.9	78.3	74.8	86.0	83.8	80.2	86.6	86.0

320SR\AU380\TABLE7.WK1

SECTION 4

PILOT SYSTEM DESIGN

INTRODUCTION

Upon completion of the pilot tests described above and in the pilot test report (appendix B), a semipermanent installation of a blower unit and a single vent well was constructed. This system is intended to operate with minimal attention for 1 full year or until the full-scale system is installed. This section describes the pertinent details of this pilot system and presents the as-built design drawings and specifications.

BASIS OF DESIGN

The pilot system in place at site ST14 was developed based on similar pilot systems constructed by ES at other locations. The goal was to leave in place a low-maintenance blower/vent well system operating to deliver air at the appropriate flow rate and pressure as indicated from the initial pilot testing. As discussed in section 3 of this report, the initial pilot testing indicated that a radius of influence in excess of 45 feet could be achieved with a nominal flow rate of 20 acfm at a nominal pressure of 2 psi. Although an equivalent radius of influence may have been achieved at a lower flow given a longer term test, ES believes that 20 acfm represents a reasonable and conservative design parameter.

DESIGN DRAWINGS AND SPECIFICATIONS

As-built design drawings are presented as sheets 1 and 2 in appendix E. These drawings present a schematic and plan and section views of both the blower/vent well pilot system and the monitoring points for the system. The vent well design is typical of all vent wells constructed at the site. Construction details of specific vent wells are included with the drilling logs in appendix D. Specifications for pilot system equipment are included on the drawings and in in additional sheets in appendix E.

RECOMMENDATIONS FOR DESIGN OF FULL SCALE SYSTEM

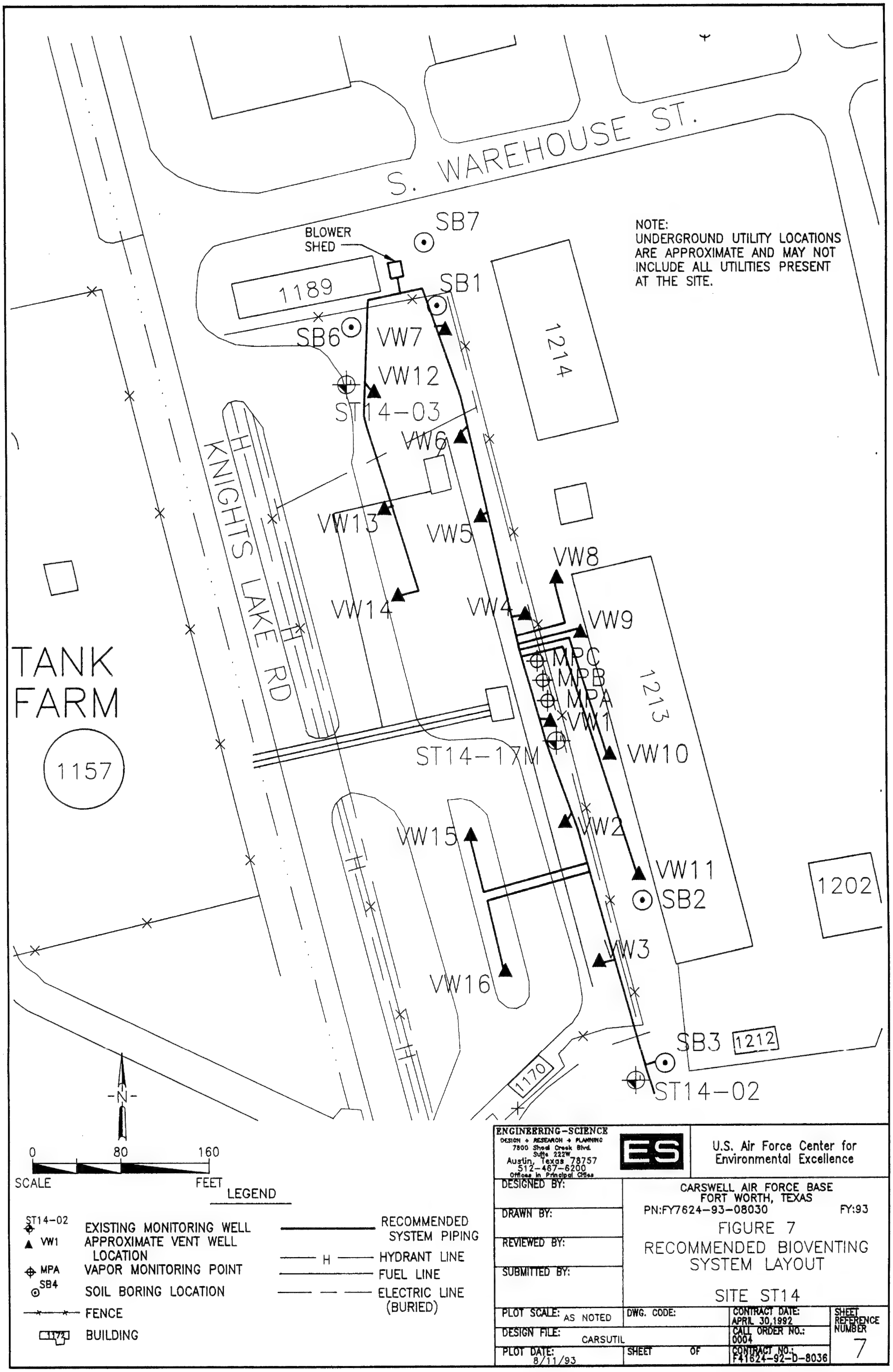
Although it is not within the scope of this delivery order to prepare a full-scale bioventing system design for ST14, some recommendations are presented here which should be considered in planning the full scale design.

As discussed in section 3, some gaps exist in available soils data for evaluating the complete extent of fuel contamination at the site. First, the limits of soil contamination to the west of the site, towards the tank farm, was not delineated. It is anticipated that the western most vent wells constructed during this investigation will provide oxygen to areas east of Knight's Lake Road which separates the site from the tank farm. Soils investigation at the tank farm should be planned to determine if contamination extends from site ST14 to the tank farm, and any bioventing system constructed at the tank farm should include treatment of any contaminated soils along Knight's Lake Road. It is anticipated that soil contamination extends under building 1213 and possibly to building 1214 east of the site. Prior to completing the full scale system, soil borings should be placed east of 1213 and between the site and building 1214 to confirm the eastern extent of soil contamination.

A recommended air delivery system layout is presented in Figure 7. It is recommended that the blower unit be housed in a shed, outside the perimeter fence for ST14, on the northern end of the site. This location allows relatively easy access to the blower shed and does not interfere with normal site activities. A header branches east and west from the outlet of the blower unit and then runs south along the east side of ST14 and south to the vent wells on the northwest end of the site. Lines branch off the header for each vent well. A vent well should be constructed at SB3 as part of this full scale system, and a soil boring should be drilled (for possible conversion to a vent well) between SB3 and SB4. This recommended configuration was developed to minimize the need to cross over underground utilities, and to limit the number of trenches crossing traffic areas.

As discussed in section 3 of this report, an air delivery rate of 15 to 20 acfm at approximately 2 psi yielded a radius of influence in excess of the 45-foot design value used for placement of the vent wells. Considering these test results, the recommended blower for the full-scale system should be capable of delivering up to 20 acfm at 2 psi to each vent well. For the sixteen vent wells in the full scale system, it is recommended that a single blower with a capacity of 320 acfm at 2 psi be installed. Because of the need for low-maintenance equipment in the full-scale system, a regenerative blower is recommended. The blower system should be installed outside explosive hazard areas unless explosion proof equipment is specified.

Upon completion of bioventing activities at the site, soil boring and sampling should be conducted to ensure that BTEX and TRPH levels in soils are acceptable. Engineering-Science recommends that borings be placed in the intervals between the vent wells to ensure that sufficient degradation of contaminants has occurred in areas furthest from the vent wells. In particular, a soil sample should be analyzed from the area between VW14 and VW15 because of the greater than normal distance between these two vent wells.


S. WAREHOUSE ST.
KNIGHTS LAKE RD
NOTE:
UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE AND MAY NOT INCLUDE ALL UTILITIES PRESENT AT THE SITE.
BLOWER SHED
SB7
SB1
SB6
SB2
SB3
1189
1214
1213
1202
1212
1170
1157
TANK FARM
VW1
VW2
VW3
VW4
VW5
VW6
VW7
VW8
VW9
VW10
VW11
VW12
VW13
VW14
VW15
VW16
MPA
MPB
MPC
ST14-03
ST14-17M
ST14-02
N
0
80
160
SCALE
FEET
LEGEND
ST14-02 EXISTING MONITORING WELL
VW1 APPROXIMATE VENT WELL LOCATION
MPA VAPOR MONITORING POINT
SB4 SOIL BORING LOCATION
FENCE
1173 BUILDING
RECOMMENDED SYSTEM PIPING
H HYDRANT LINE
FUEL LINE
ELECTRIC LINE (BURIED)
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DRAWN BY:
REVIEWED BY:
SUBMITTED BY:
CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS
PN:FY7624-93-08030
FY:93
FIGURE 7
RECOMMENDED BIOVENTING SYSTEM LAYOUT
SITE ST14
PLOT SCALE: AS NOTED
DWG. CODE:
CONTRACT DATE: APRIL 30,1992
SHEET REFERENCE NUMBER
DESIGN FILE: CARSUTIL
CALL ORDER NO.: 0004
PLOT DATE: 8/11/93
SHEET OF
CONTRACT NO.: F41624-92-D-8036
7

Appendix A

Work Plan

Bioventing Test Work Plan
for Petroleum, Oil, and
Lubricant Tank Farm
Site ST14
Carswell AFB, Texas

Contract F41624-92-D-8036

Prepared for
Air Force Center for
Environmental Excellence
Brooks AFB, Texas

Prepared by

Engineering-Science, Inc.
Austin, Texas

April 1993

CONTENTS

FIGURES

FIGURES

BIOVENTING TEST WORK PLAN FOR PETROLEUM, OIL, AND LUBRICANT TANK FARM – SITE ST14 CARSWELL AFB, TEXAS

1.0 INTRODUCTION

This work plan presents the scope of an *in situ* bioventing pilot test for treatment of fuel-contaminated soils and a subsurface soils investigation at the petroleum, oil, and lubricant (POL) tank farm (site ST14) at Carswell Air Force Base (AFB), Texas. The pilot test has three primary objectives: 1) to assess the potential for supplying oxygen throughout the contaminated soil interval; 2) to determine the rate at which indigenous microorganisms will degrade fuel when stimulated by oxygen-rich soil gas; and 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory limits. The objective of the subsurface soils investigation is to delineate the extent of contamination at the site.

The pilot test will be conducted in two phases. Vent wells (VWs) and monitoring points (MPs) will be installed during site investigation activities. The initial stage will also include an *in situ* respiration test and an air permeability test. This initial testing is expected to take approximately 2 weeks. If successful, ES will proceed directly into the second phase of testing. During the second phase, a bioventing system will be installed and monitored over a 1-year period.

If bioventing proves to be feasible, pilot test data could be used to design a full-scale remediation system and to estimate the time required for site cleanup. The soils investigation will provide additional data on subsurface contamination to guide design of the full-scale bioventing system at this site. An added benefit of the pilot testing at the POL tank farm is that a significant amount of the fuel contamination should biodegrade during the 1-year pilot test, as the testing will take place within known contaminated soils at the site.

Additional background information on the development and recent success of the bioventing technology is found in the *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Hinchee et al., 1992). This protocol document will also serve as the primary reference for pilot test well designs and detailed procedures which will be used during the test.

2.0 SITE DESCRIPTION

2.1 Site Location and History

The POL tank farm, also referred to as site ST14, is located in the eastern portion of the base, near the Carswell AFB main gate. The tank farm portion of the site consists of two aboveground fuel storage tanks. The site also includes the fuel loading facility located on the east side of Knights Lake Road, across the street from the tank farm. Figure 2.1 shows the locations of existing tanks, general site features, and monitoring wells within and adjacent to the areas identified with fuel contamination. Soil gas survey results indicate probable subsurface soils contamination in the vicinity of the aboveground tanks and near the monitoring well, ST14-17M (Radian, 1991a). Free-floating product was encountered in this monitoring well during a 1990 Investigation Restoration Program (IRP) investigation event. It is suspected that subsurface soils in the fuel loading facility were contaminated through leaking underground pipes. A French drain system was reportedly installed downgradient of the site to collect and discharge oily wastes through an oil-water separator located at the base.

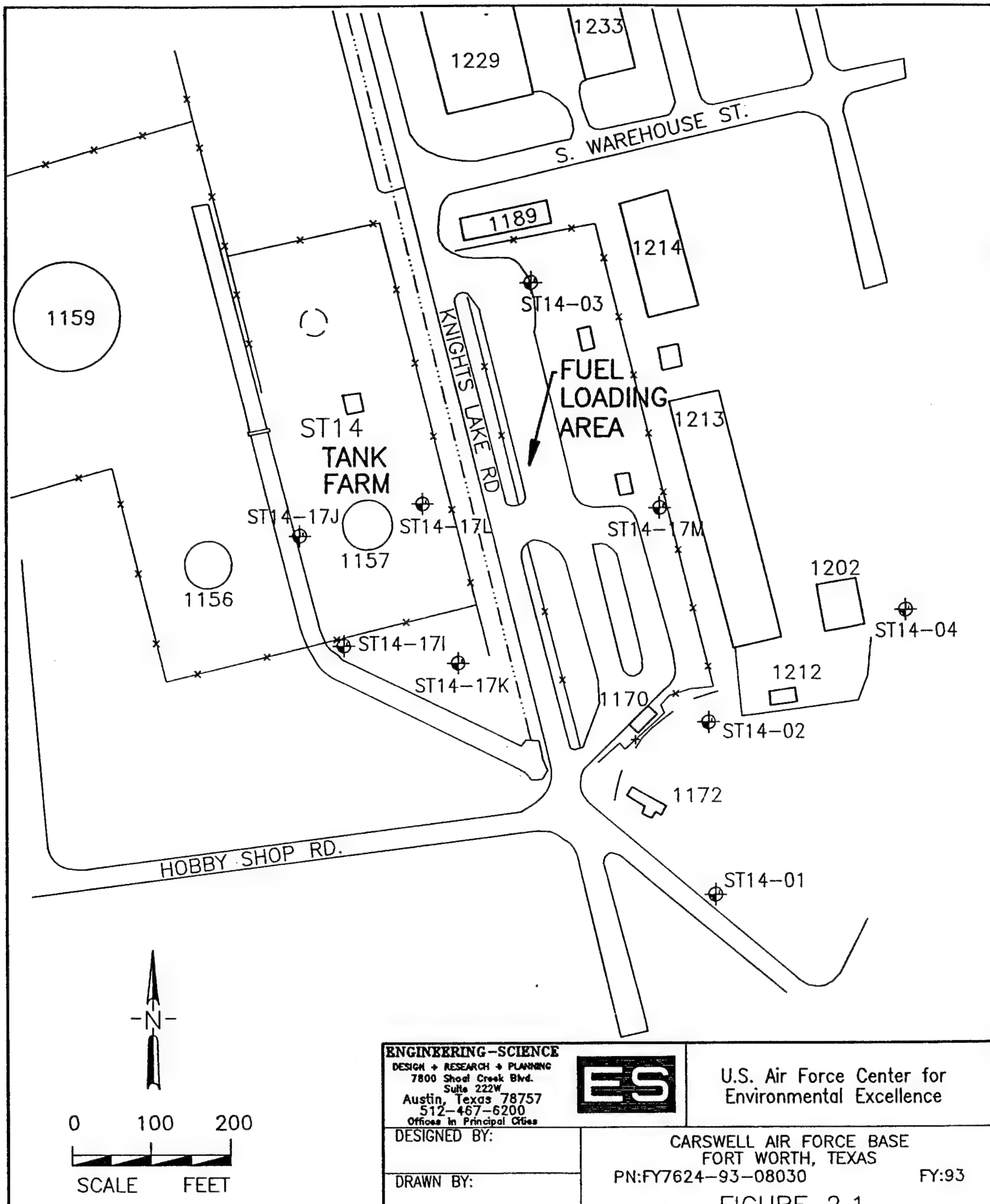
2.2 Site Geology

According to information obtained during installation of the nine monitoring wells and drilling of eight soil borings in and around the site vicinity, the upper zone in the POL tank farm area consists of approximately 10 feet of gray to tan clay (Radian, 1991a). The clay was reported to contain pebbles and freshwater gastropod shells. This upper zone is underlain by another 5 to 10 feet of fine-grained greyish-green or tan sand and gravel, increasing in gravel content with depth. The gravel ranges from pea size to over an inch in diameter. Beneath this sand and gravel layer lies the underlying bedrock surface of the Goodland Limestone Formation. The depth to the Goodland limestone beneath the site ranges from 16 to 20 feet below ground level (BGL) (Radian, 1991a).

A water-level survey performed on wells in June 1990 at the site indicated the depth to water varied from approximately 8 to 16 feet BGL (Radian, 1991a). This suggests that the top of the water table corresponds fairly closely to the top of the sand and gravel layer. In monitoring well ST14-17M, located near the proposed vent well, groundwater was encountered at approximately 10 feet BGL.

2.3 Site Contaminants

The primary contaminants at this site are believed to be petroleum hydrocarbons, which have been detected in groundwater samples collected at site ST14 (Radian, 1991b). These petroleum components are benzene, ethyl benzene, chlorobenzene, toluene, and xylenes. Of these, ethyl benzene was the most common, having been detected in six of the nine monitoring wells at the site. Benzene was the only volatile organic compound detected at a concentration exceeding its maximum contaminant level (MCL). Analytical results reveal the highest benzene concentrations in the groundwater sample collected from monitoring well ST14-17M in the fuel loading facility. More than 2 feet of free-



LEGEND

ST14-02 MONITOR WELL

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DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93 FIGURE 2.1 SITE LAYOUT WITH EXISTING MONITORING WELL LOCATIONS SITE ST14
DRAWN BY:	
REVIEWED BY: B.R. VANDERGLAS	
SUBMITTED BY: J.D. HIGHLAND	

PLOT SCALE: AS NOTED	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 2.1
DESIGN FILE: SITECARS		CALL ORDER NO.: 0004	
PLOT DATE: 4/26/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	

phase hydrocarbon was also encountered floating on top of the water in this monitoring well during the 1990 sampling event. The highest levels of chlorobenzene, toluene, and total xylenes were also detected in the sample collected from this well.

The results of a soil gas survey conducted in December 1987 at the site also indicated the probable presence of hydrocarbon-contaminated subsurface soils in two separate areas beneath the site (Radian, 1991a). The largest vapor plume was reported underlying the vicinity of tanks 1156 and 1157 and encompassing an area approximately 100 feet wide and 300 feet long. A smaller plume was encountered in the fuel loading facility area located near monitoring well ST14-17M, which exhibited free-floating product during the 1990 groundwater sampling activities.

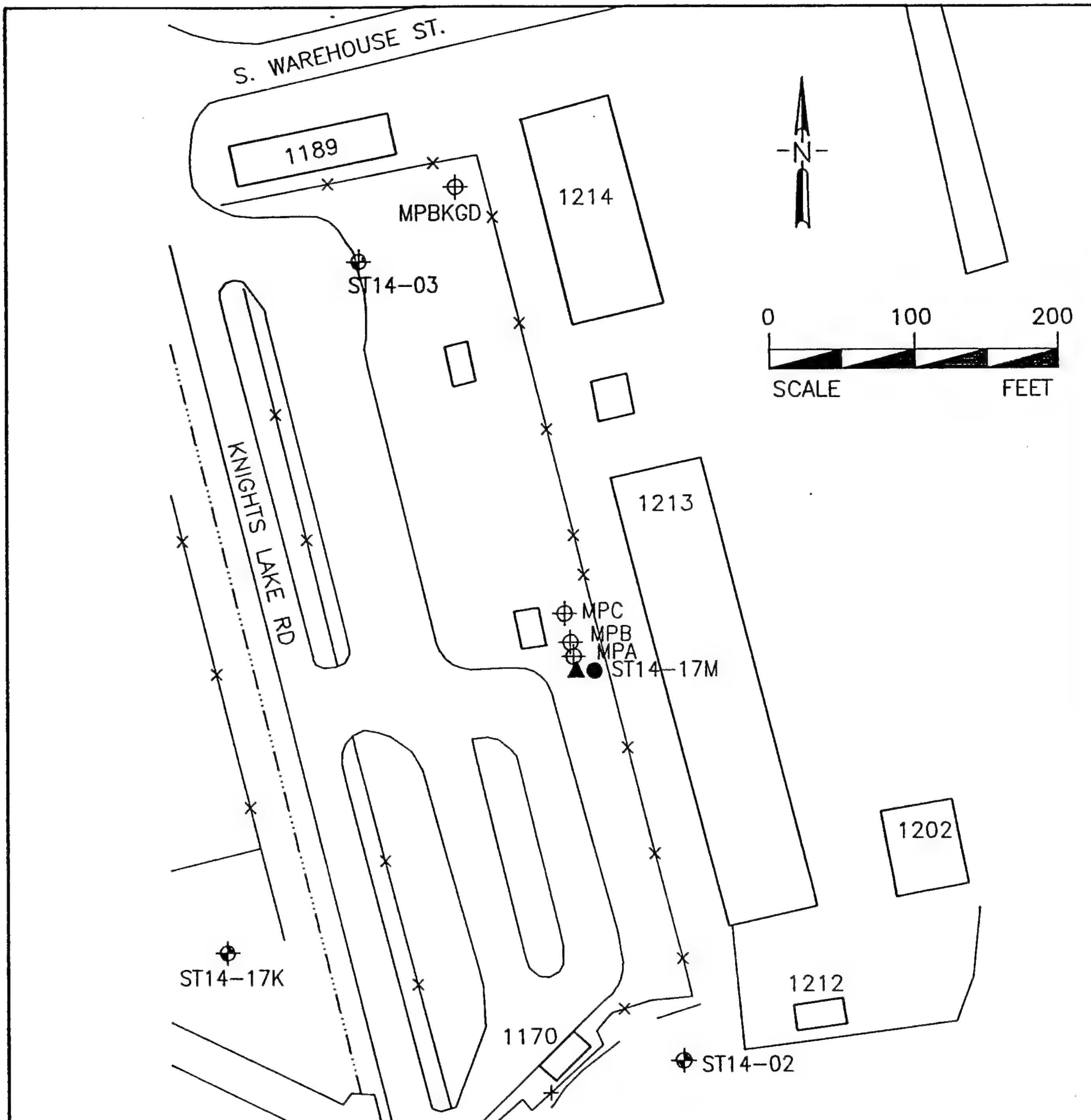
The results of any soil sampling activities which may have taken place are not available. As discussed in section 5.0, soil sampling is planned to fill in this data gap.

3.0 PILOT TEST ACTIVITIES

The purpose of this section is to describe the work that will be performed by Engineering-Science, Inc. (ES), at site ST14 (POL tank farm) during the bioventing pilot test. ES will perform siting and construction of a central air injection VW and three vapor MPs; an *in situ* respiration test; an air permeability test; and installation of a long-term bioventing pilot test system. Soil borings will also be drilled to more fully characterize and delineate the soil contamination of the vadose zone in the vicinity of the POL tank farm. If significant fuel contamination is encountered during soil boring activities, then additional VWs may be constructed in the contaminated borehole for potential use in full-scale remediation, depending on pilot test results. Pilot test activities performed on any additional wells will be limited to field screening of soil gas samples. Soil and gas sampling procedures and the blower configuration that will be used to inject air (oxygen) into contaminated soils through the central VW are also discussed in this section. The soil sampling plan for the vadose zone contamination investigation is described in section 5. No dewatering will take place during the pilot test. Pilot test activities will be confined to unsaturated soils remediation. Existing monitoring wells will not be used as primary air injection wells. However, monitoring wells which have a portion of their screened interval above the water table may be used as vapor MPs or to measure the composition of background soil gas.

3.1 Site Layout

Criteria for siting a central VW and vapor MPs are described in the protocol document (Hinchee et al., 1992). Figure 3.1 illustrates the proposed locations of the central VW and the MPs at this site. The final locations may vary slightly from the proposed locations if significant fuel contamination is not observed in the boring for the VW. Based on existing site investigation data, the central VW should be located



LEGEND

▲ PROPOSED CENTRAL VENT WELL (AIR INJECTION)

ST14-17M ● EXISTING MONITORING WELLS

MPC ⌖ PROPOSED VAPOR MONITORING POINT

—x—x— FENCE

| 1213 | BUILDING

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DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93		
DRAWN BY:	FIGURE 3.1 PROPOSED VENT WELL/VAPOR MONITORING POINT LOCATIONS SITE ST14		
REVIEWED BY: B.R. VANDERGLAS			
SUBMITTED BY: J.D. HIGHLAND			
PLOT SCALE: AS NOTED	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 3.1
DESIGN FILE: SITECARS		CALL ORDER NO.: 0004	
PLOT DATE: 4/26/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	

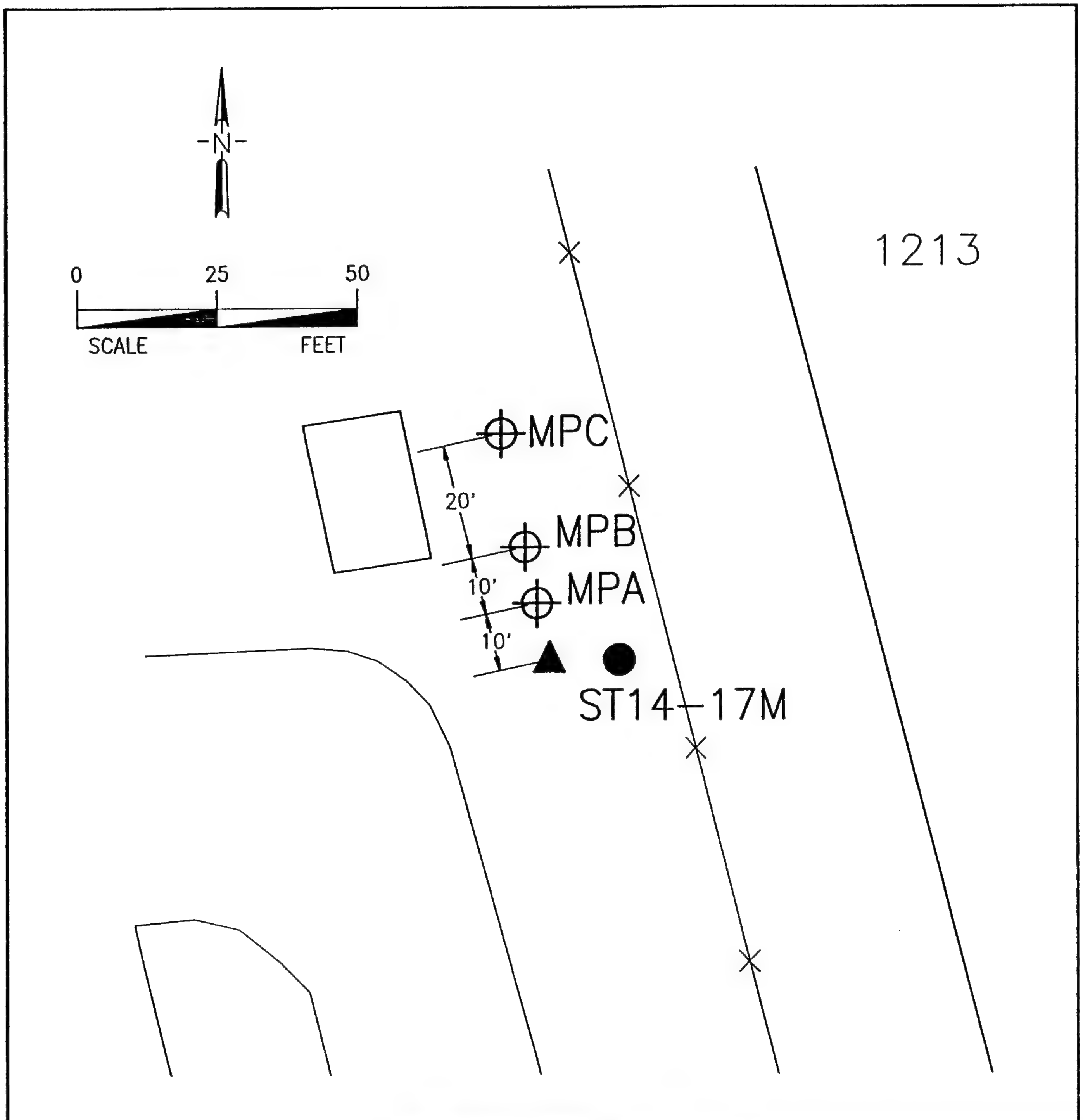
near, and west of, monitoring well ST14-17M. Soils in this area are expected to be oxygen depleted (<2 percent) by high hydrocarbon levels, and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during pilot test operations.

Given the relatively shallow depth of contamination at this site and the experience that ES has had with similar soil types, the potential radius of venting influence around the central air injection well is expected to be 35 to 40 feet. Three vapor MPs (referred to as MPA, MPB, and MPC) will be located within a 40-foot radial distance of the central VW. The spacing of the monitoring points in relation to the vent well is shown on Figure 3.2. A fourth MP will be located away from the site in clean soils and will be used to measure background levels of oxygen and carbon dioxide and to determine if natural carbon sources are contributing to oxygen uptake during the *in situ* respiration test. This background MP is tentatively located on Figure 3.1. However, ES will request the assistance of base personnel in identifying an uncontaminated area for background sampling.

3.2 Vent Well

One central VW will be installed at the site. The central VW will be used, for pilot testing purposes and will be constructed of 4-inch-inside-diameter (ID) schedule 40 polyvinyl chloride (PVC), with a 10-foot interval of 0.04-inch slotted screen set at 5 to 15 feet BGL. Flush-threaded PVC casing and screen will be used with no organic solvents or glues. The filter pack will be clean, well-rounded silica sand with a grain size of 6 to 9, and will be placed in the annular space of the screened interval. A 2-foot layer of bentonite pellets, hydrated in place with potable water, will be placed directly over the filter pack. This layer of pellets will prevent the addition of bentonite slurry from saturating the filter pack. A bentonite-cement grout will then be tremied into the remaining annular space above the bentonite pellets to produce an airtight seal above the screened interval. A complete seal is critical to prevent injected air from short-circuiting to the surface during the bioventing test. Figure 3.3 illustrates the proposed central VW construction for this site.

Although contaminated soils may exist above 5 feet BGL, the 5-foot depth was chosen for the top of the screened interval to reduce short-circuiting of injected air to the surface, a common problem at sites with shallow contamination and tight soils. It is felt that oxygen can still be delivered to the shallow soils by vertical flow and diffusion. The bottom of the screened interval 15 feet BGL will be 5 feet below the interface of silty-clay and sand, which is approximately 10 feet BGL. Water is anticipated to be present in the top of the sand zone at approximately 11 feet BGL. The June 1990 water level reported for monitoring well ST14-17 was 10.9 feet below the measuring point. Placing the screened interval well into the water table will allow oxygenation of soils in this zone if the water table subsides during the life of the pilot system.



LEGEND

▲ PROPOSED CENTRAL VENT WELL (AIR INJECTION)

ST14-17M ● EXISTING MONITORING WELLS

MPC ⌖ PROPOSED VAPOR MONITORING POINT

FENCE

1213 BUILDING

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DRAWN BY:	FIGURE 3.2
REVIEWED BY: B.R. VANDERGLAS	PROPOSED VENT WELL/VAPOR MONITORING POINT SPACING
SUBMITTED BY: J.D. HIGHLAND	SITE ST14

PLOT SCALE: AS NOTED	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER
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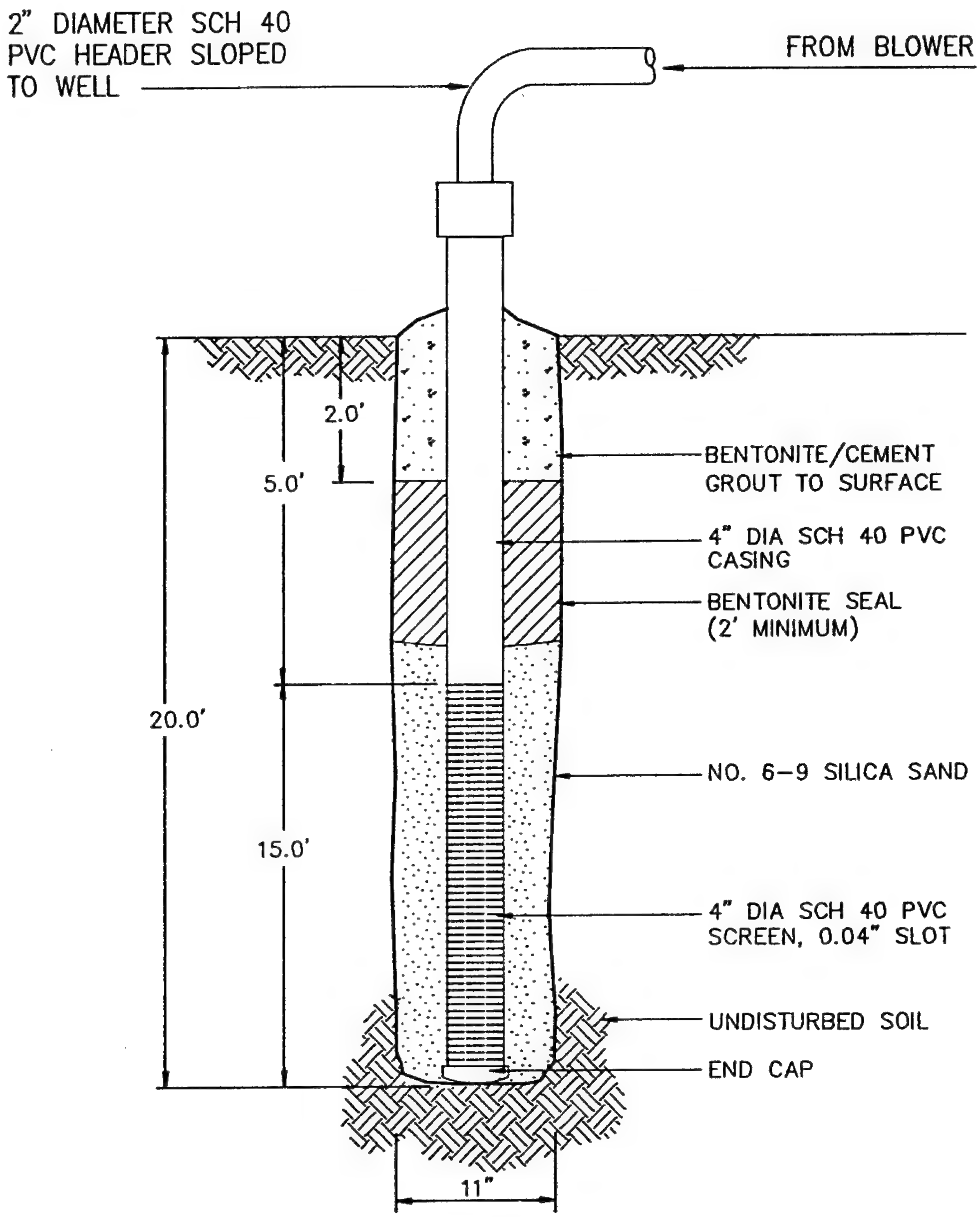
PLOT DATE: 4/26/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	



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DRAWN BY:

REVIEWED BY:
B.R. VANDERGLAS

SUBMITTED BY:
J.D. HIGHLAND

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FIGURE 3.3
INJECTION VENT WELL CONSTRUCTION DETAIL

SITE ST14

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DESIGN FILE: DETLCARS		CALL ORDER NO.: 0004	
PLOT DATE: 4/26/93	SHEET 1 OF 1	CONTRACT NO.: F41624–92–D–8036	

3.3 Monitoring Points

A typical multidepth vapor MP construction for this site is shown in Figure 3.4. Soil gas oxygen and carbon dioxide concentrations will be monitored at depths of 4 feet, 7 feet, and 10 feet at each location. Where the water table is less than 10 feet BGL, only two MPs may be constructed. Multidepth monitoring will confirm that the entire soil profile is receiving oxygen, and will serve to measure fuel biodegradation rates at each depth. The depths or number of monitoring points will be adjusted in the event the water table is encountered at depths shallower than 10 feet, such that the deepest monitoring point screen is a minimum of 1 foot above the water table. The spaces between monitoring intervals will be sealed with bentonite to isolate the intervals. As with the central VW, several inches of hydrated bentonite pellets will be used to shield the filter pack from rapid infiltration of bentonite slurry additions. Soil temperature will be monitored using thermocouples installed at depths of 4 feet and 10 feet BGL in the monitoring point closest to the vent well (MPA). Additional details on VW and MP construction are found in section 4 of the protocol document.

3.4 Handling Drill Cuttings

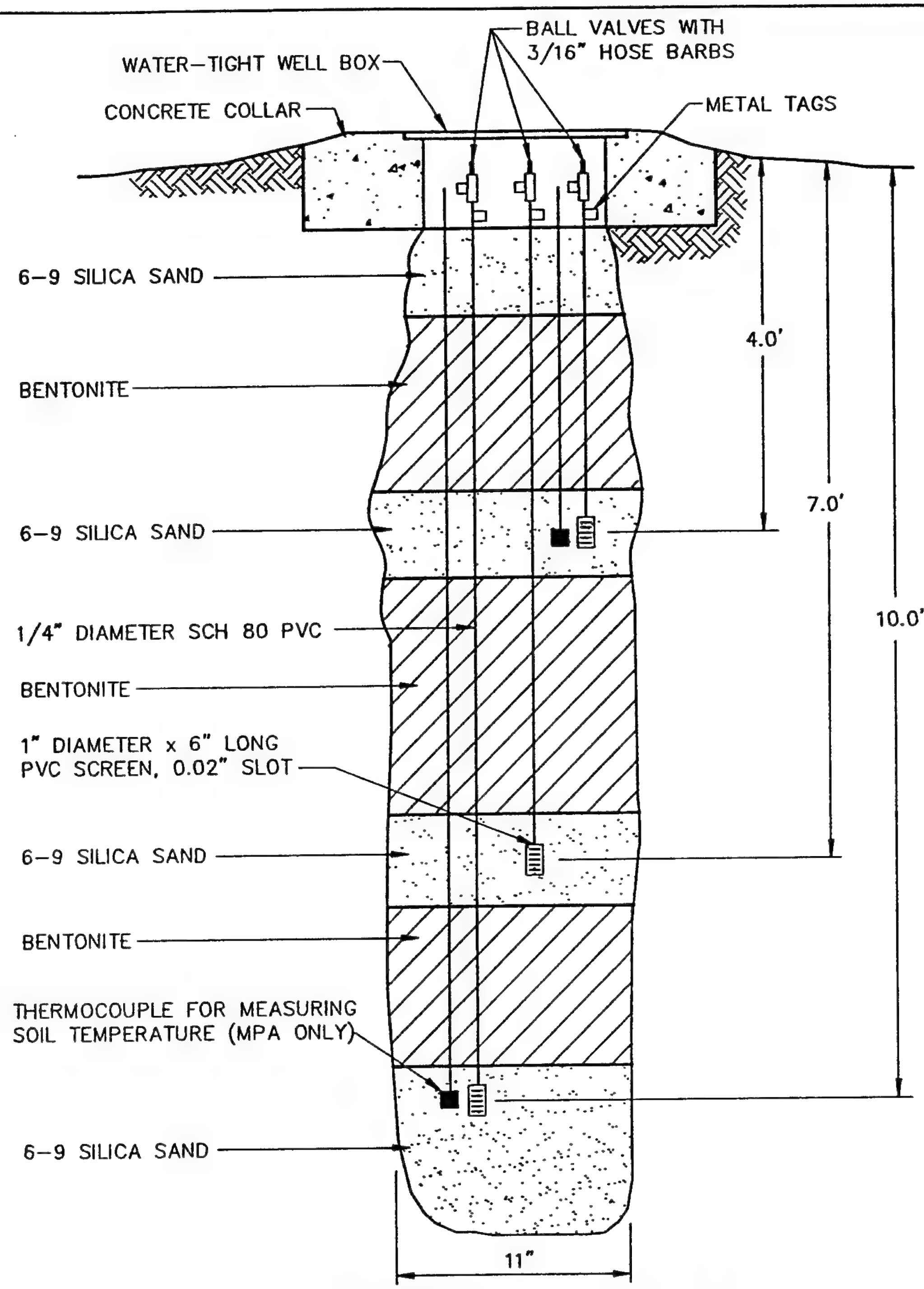
Cuttings will be collected in U.S. Department of Transportation (DOT) approved containers. The containers will be labeled and left on base. Drill cuttings will become the responsibility of Carswell AFB or their designated contractor. Thus, Carswell AFB will be responsible for disposal of drill cuttings in accordance with the current procedures for ongoing remedial investigations.

3.5 Soil and Soil Gas Sampling

3.5.1 Soil Samples

Four soil samples will be collected from the pilot test area during installation of the central VW and MPs. Sampling procedures will follow those outlined in the protocol document. One sample will be collected from the most contaminated interval of the central VW boring, and one sample will be collected from the interval of highest apparent contamination in each of the MP soil borings. Soil samples will be analyzed for total recoverable petroleum hydrocarbons (TRPH) using EPA method 418.1; benzene, toluene, ethyl benzene, and xylenes (BTEX) using EPA method SW8020; soil moisture; pH; particle sizing; alkalinity; and nutrients (nitrogen and phosphorus). One sample from the background boring will also be analyzed for total Kjeldahl nitrogen (TKN).

Samples for TRPH and BTEX analysis will be collected using a split-spoon sampler. Samples will be collected by hand with stainless steel sampling spoons or using brass tube liners in the split spoon. Hand collected samples will be immediately placed in glass bottles with Teflon®-lined lids and packed into a cooler for storage. If brass tube liners are used, the soil samples will be immediately trimmed, and the ends of the brass tubes will be sealed with aluminium foil or Teflon fabric held in place by plastic caps. Soil samples collected for all other analyses will be placed into glass sample jars or other appropriate sample containers specified in the soil sampling section of this work plan (section 5). Soil samples will be labeled



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DRAWN BY:	FIGURE 3.4
REVIEWED BY: B.R. VANDERGLAS	MONITORING POINT CONSTRUCTION DETAIL
SUBMITTED BY: J.D. HIGHLAND	SITE ST14

PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 3.4
DESIGN FILE: DETLCARS		CALL ORDER NO.: 0004	
PLOT DATE: 4/26/93	SHEET 1 OF 1	CONTRACT NO.: F41624–92–D–8036	

following the nomenclature specified in the protocol document, wrapped in plastic, and placed in a cooler for shipment. A chain-of-custody form will be filled out, and the cooler will be delivered to NDRC Laboratories in Richardson, Texas, for analysis. This laboratory has been audited by the Texas Water Commission (TWC) and meets all quality assurance/quality control (QA/QC) and certification requirements for the State of Texas.

3.5.2 Soil Gas Samples

A total hydrocarbon vapor analyzer will be used during drilling to screen split-spoon samples for intervals of high fuel contamination in the VWs and MPs. Initial soil gas samples from the central VW and from the MPs closest to and furthest from the VW will be collected in SUMMA® canisters in accordance with the bioventing field sampling plan (ES, 1992). Additionally, these soil gas samples will be used to determine the reduction in BTEX and total volatile hydrocarbons (TVH) during the 1-year test, and to detect any migration of these vapors from the source area.

Soil gas sample canisters will be placed in a small cooler and packed with foam pellets to prevent excessive movement during shipment. To prevent condensation of hydrocarbons, samples will not be sent on ice. A chain-of-custody form will be filled out, and the cooler will be shipped to the Air Toxics, Inc., laboratory in Ranch Cordova, California, for analysis.

3.6 Blower System

A 3-horsepower positive-displacement blower capable of injecting air over a wide range of flow rates and pressures will be used to conduct the initial air permeability test and *in situ* respiration test. The maximum power requirement anticipated for this pilot test is 230-volt, single-phase, 30-amp service. Additional details on power supply requirements are described in section 6.0, base support requirements.

3.7 In Situ Respiration Test

The objective of the *in situ* respiration test is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at selected depth intervals in MPs where bacteria biodegradation of hydrocarbons is indicated by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. A 1-cubic-foot-per-minute (cfm) pump will be used to inject air into the selected MP depth intervals containing low levels (<2 percent) of oxygen. A 20-hour air injection period will be used to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals. Helium will also be injected at each MP to account for oxygen loss to diffusion or leakage. Additional details on the *in situ* respiration test are found in section 5.7 of the protocol document (Hinchee et al., 1992).

3.8 Air Permeability Test

The objective of the air permeability test is to determine the extent of the subsurface that can be oxygenated using one air injection VW. Air will be injected into the 4-inch-diameter central VW using the blower unit, and pressure response will be measured at each MP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the MPs to verify that oxygen levels in the soil increase as the result of air injection. One air permeability test lasting approximately 4 to 8 hours will be performed.

3.9 Installation of 1-Year Pilot Test Bioventing System

The decision to proceed with bioventing will be made after completion of the soil gas permeability and the *in situ* respiration tests. If sufficient evidence exists to indicate that the addition of oxygen enhances biodegradation in the contaminated areas, then a long-term bioventing system will also be installed at the POL tank farm area (site ST14) before the field crew leaves the site. The base will be requested to provide power consisting of 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles. Depending on availability, a base electrician or a licensed electrician subcontracted to ES will assist in wiring the blowers to line power. The blower system will be chosen based on the results of the initial respiration and air permeability tests. However, it is anticipated that the long-term blower will be capable of injecting air at 5 pounds per square inch (psi) and 14 cfm and will not exceed 1.5 horsepower. The blower will have vacuum, pressure, and temperature gauges, and an air filter, pressure relief, and flow control valve (see Figure 3.5). The blower will be housed in a small, prefabricated shed to provide protection from the weather. The system will be operated for 1 year, and ES personnel will conduct *in situ* respiration tests after 6 months and at the conclusion of the pilot test (1 year) to monitor the long-term performance of this bioventing system. Weekly system checks will be performed by Carswell AFB personnel. If required, major maintenance of the blower unit will be performed by ES personnel. Detailed blower system information and a maintenance schedule will be included in the operation and maintenance (O&M) manual provided to the base. More detailed information regarding the long-term pilot test procedures can be found in the protocol document.

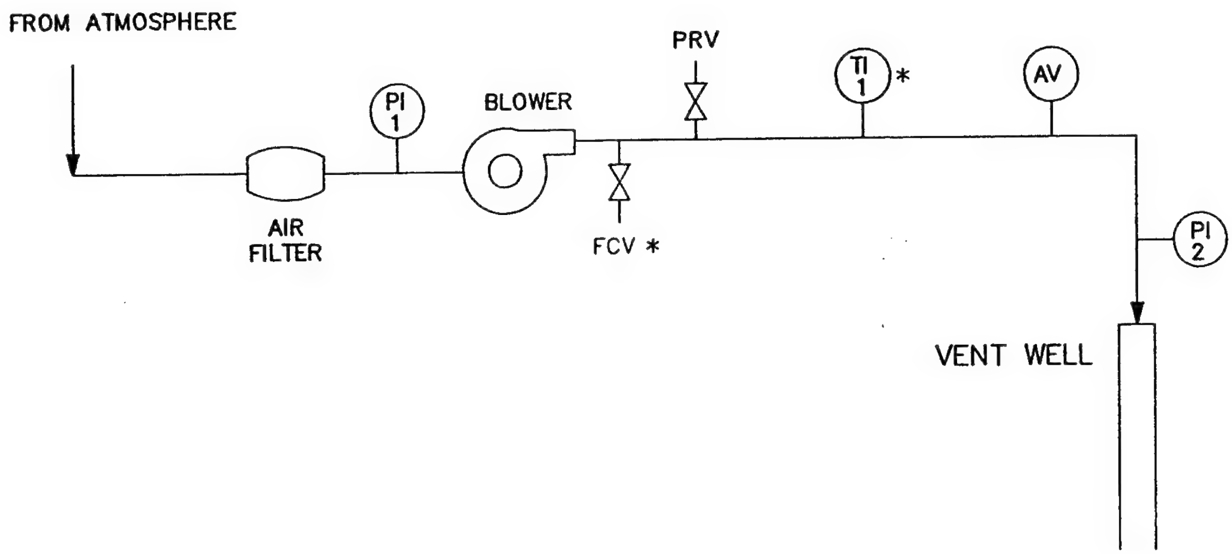
4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used to measure the air permeability of the soil and *in situ* respiration rates are described in sections 4 and 5, respectively, of the protocol document (Hinchee et al., 1992). No exceptions to the protocol are anticipated.

5.0 SOIL SAMPLING PLAN

5.1 Preliminaries

Prior to drilling, all federal, state, and local permits will be obtained and all underground pipelines and utilities will be marked. Carswell AFB will be responsible for assisting the ES field team in obtaining all utility clearances. If any of the proposed borehole locations are in a difficult drilling position, such as under a tree,



LEGEND

AV AIR VELOCITY GAUGE

PI 1 PRESSURE INDICATOR

TI 1 TEMPERATURE INDICATOR

FCV FLOW CONTROL VALVE

PRV PRESSURE RELIEF VALVE

* OPTIONAL

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DRAWN BY:	FIGURE 3.5
REVIEWED BY: B.R. VANDERGLAS	BLOWER SYSTEM INSTRUMENTATION DIAGRAM
SUBMITTED BY: J.D. HIGHLAND	FOR AIR INJECTION SITE ST14

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too close to an overhead power line, or in an unusually soft or wet area, then the borehole will be relocated by the ES field team leader.

To ensure that no contamination is inadvertently introduced into a boring or vent well, all drilling, downhole, and sampling equipment will be decontaminated. The driller on site will have a valid State of Texas monitoring well license.

To further ensure that there are no underground obstructions, all areas where soil borings and vent wells are to be drilled will be surveyed with a magnetometer (pipe finder) instrument.

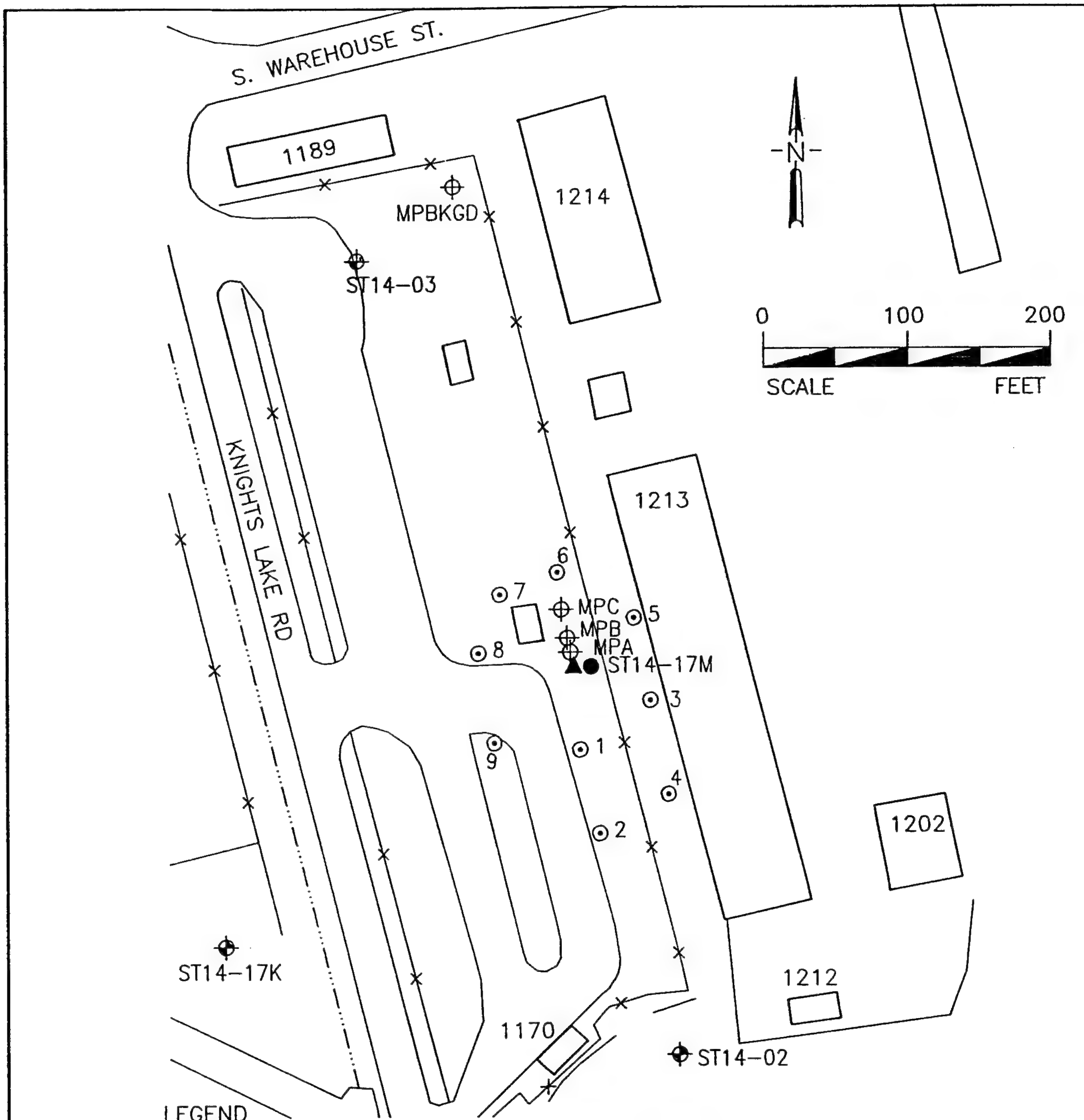
5.2 Drilling

The soil borings will be drilled to a depth of approximately 10 to 15 feet using 8-inch-outer-diameter (OD), continuous-flight, hollow-stem augers. Soil samples will be collected continuously using a split spoon or core barrel. The lithology of each sample will be described in the field logbook.

Once the radius of oxygen influence (ROI) for vent wells at the site is determined from the pilot bioventing test, the soil boring locations can be determined. The borings will be located generally along the buried fuel distribution line. The ROI observed from the pilot system will be used to determine the spacing between soil borings in order to maximize efficiency of a full-scale bioventing system. The proposed locations for the first nine boreholes are shown on Figure 5.1. These locations account for cultural obstructions such as buildings and pavement, but do not consider results obtained during the pilot test. A more accurate soil boring plan with tentative boring locations will be prepared after determining ROI and evaluating analytical data from samples collected from the vent well and monitoring point boreholes. This plan will be submitted as an appendix to the interim bioventing test data report.

The core samples will be screened with an OVA, and at least one sample per boring will be placed into a jar for headspace analysis. If contamination is not found by screening the soil, then no further borings will be drilled. If significant contamination is detected based on headspace readings or saturated visual characteristics, then a vent well will be completed in the borehole for use in the full-scale bioventing system. A second soil boring will be drilled and sampled one and three-fourths ROIs from the first. If contamination is still detected, then additional borings will be drilled until significant contamination is no longer detected. Vent wells will be constructed in each of the borings which exhibit characteristics of significant contamination (i.e., high headspace readings, oily saturated soil, heavy odors).

Soil borings will also be located in a line downgradient of the area of highest contamination based on local groundwater hydrology. The water table is located near a depth of 10 feet, so subsurface soil contamination is likely to occur downstream of the contaminant source since the groundwater is one of the probable migration pathways for contamination. The borings will be spaced according to data provided during the pilot test.



LEGEND

▲ PROPOSED CENTRAL VENT WELL (AIR INJECTION)

ST14-17M ● EXISTING MONITORING WELLS

MPC ⊕ PROPOSED VAPOR MONITORING POINT

—×—×— FENCE

1213 BUILDING

⊙ 2 PROPOSED SOIL BORING LOCATION

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ES

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DESIGNED BY:

DRAWN BY:

REVIEWED BY:
B.R. VANDERGLAS

SUBMITTED BY:
J.D. HIGHLAND

CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS
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FIGURE 5.1
PROPOSED INITIAL BOREHOLE LOCATIONS

SITE ST14

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SHEET REFERENCE NUMBER 5.1
DESIGN FILE: SITECARS
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PLOT DATE: 4/26/93
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CONTRACT NO.: F41624-92-D-8036

Once the extent of migration is determined along the pipeline and downgradient of the area of highest contamination, then additional soil borings will be drilled radially from the pilot vent well to determine the extent of contamination in other directions. If the extent of contamination is adequately determined without expending the drilling budget, then some additional soil borings may be located around the POL tank farm area to begin characterization and delineation activities there.

5.3 Sampling

Soil samples will be continuously collected and lithologically described. Samples will also be collected for chemical analysis. Once the samples are retrieved from the augers, the soil will be scanned with a flame ionization detector (FID) to check for contamination. If contamination is suspected, then some of the sample will be placed in a Mason jar and covered with foil for a headspace analysis.

A maximum of two samples will be collected from each boring. One sample will be collected from just above water (about 10 feet below ground) where the highest contamination is anticipated. A second sample will be collected from any other zones which exhibit high contamination based on the screening results, but preferably in the screened interval of the vent wells (5 to 10 feet BGL). The soil samples from each boring will be analyzed for the BTEX and TRPH. It is anticipated that on average one and one-half samples will be collected per boring.

Once the samples have been retrieved from the sampling device, they will be immediately placed in 8-ounce glass jars (if brass tube liners are not used). If brass tubes are used, then the samples will be immediately trimmed, and the ends of the brass tubes will be sealed with aluminum foil or Teflon fabric held in place by plastic caps.

5.4 Chain of Custody

Sample Labels

To prevent misidentification of samples, labels will be affixed to each sample container. The labels will be sufficiently durable to remain legible even when wet and will contain the following types of information:

- Sample identification number
- Name of collector
- Date and time of collection
- Place of collection
- Parameter(s) requested (if space permits).

The sample labels will be filled out with waterproof ink. Clear cellophane tape will be placed over the label for protection.

Sample Seal

In cases where samples may leave the owner-operator's immediate control, such as shipment to a laboratory by a common carrier (e.g., air freight), a seal will be

affixed to the shipping container or individual sample bottles to ensure that the samples have not been disturbed during transportation. The seal, which may consist of an adhesive sticker with the date and the sample name written on it, will be placed on the shipping container or bottle in such a way that opening of the container or bottle will cause removal of or damage to the seal.

Field Logbook

A project record book will be maintained by the ES field leader during all field activities at the site. All information (except drill logs and record sheets for respiration and air permeability tests) pertinent to field activities (including instrument calibration data) will be recorded daily in the project-designated field logbooks. These books will be bound, and pages will be consecutively numbered. Entries in the logbook will be made in waterproof ink, and each page will be signed and dated. At a minimum, the following information will be entered in the field logbooks:

- Name and title of author, date and time of entry, and environmental conditions during field activity
- Location of sampling activity
- Name and title of field crew
- Sample medium (i.e., soil)
- Sample collection method
- Number and volume of sample(s) taken and sample identification numbers
- Date and time of collection
- Sample distribution (i.e., laboratory)
- Field observations
- Health and safety information such as air monitoring, heat or cold stress monitoring data, upgrades or downgrades of personal protective equipment, and the reasons for such upgrades or downgrades.

In addition, the following observations about each sample collected will be recorded in the logbooks as appropriate:

- Sample depth
- Color and texture
- Physical description
- Type(s) of laboratory analyses requested
- Any changes in sampling locations (also to be indicated on annotated maps).

In summary, sufficient information will be recorded in the field logbooks during field activities to permit reconstruction of the sampling event without reliance on the collector's memory.

If an error is made on an accountable document assigned to one individual, the individual will make all corrections simply by crossing a line through the error and entering the correct information. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All subsequent corrections must be initialed and dated.

Chain-of-Custody Record

To establish the documentation necessary to trace sample possession from time of collection, a chain-of-custody record will be filled out and will accompany every sample. The record will contain the following types of information:

- Sample number
- Signature of collector
- Date and time of collection
- Sample type
- Identification of boring
- Number of containers
- Parameters requested for analysis
- Signature of person(s) involved in the chain of possession
- Inclusive dates of possession.

6.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of the drilling subcontractor and the ES pilot test team:

- Confirmation of regulatory approval of work plan before proceeding.
- Assistance in obtaining drilling and digging permits.
- Confirmation of available power source, specifically 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles. The breaker box should be located as close as practical to the VW location (Figure 3.1), preferably outside the fenced area.
- Provision of any paperwork required to obtain gate passes and security badges for approximately three ES employees, two drillers, and an electrician (if a base electrician is not available). Vehicle passes will be needed for one truck and trailer and a drill rig.

During the initial testing, the following base support is needed:

- Twelve square feet of desk space and a telephone in a building located as close to the site as practical
- Assistance in locating area (not likely to be affected by petroleum contamination) for background soil boring

- The use of the base wastewater treatment facility or other discharge for disposal of decontamination liquids
- Acceptance by Carswell AFB of responsibility for drill cuttings from VW and MP borings, including any drum sampling to determine hazardous waste status. (If ES is to transfer custody of barrels to another contractor working on the base, assistance in arranging this transfer will also be needed.)

During the 1-year extended pilot test, base personnel will be required to perform the following activities:

- Check the blower system once per week to ensure that it is operating and to record the air injection pressure. ES will provide a brief training session on this procedure.
- If the blower stops working, notify David Highland or Brian Vanderglas of ES Austin (512/467-6200); or Chris Hobbins of the Air Force Center for Environmental Excellence (AFCEE) (210/536-5261).
- Arrange site access for an ES technician to conduct *in situ* respiration tests approximately 6 months and 1 year after the initial pilot test.

7.0 PROJECT AND DELIVERABLES AND SCHEDULE

The following schedule is contingent upon approval of this pilot test work plan and fulfillment of base support requirements.

Event	Date Completed
Draft pilot test work plan to AFCEE/Carswell AFB	22 April 1993
Begin initial pilot test	17 May 1993
Analytical report	20 July 1993
Scientific test	20 July 1993
Technical report	11 August 1993

Upon receipt of laboratory results, ES will prepare and submit an analytical report (referred to as data item A003 in the statement of work) consisting of the project analytical data and appropriate observations and explanations. A scientific report (referred to as data item A004 in the statement of work) will be submitted presenting the draft pilot test report. Upon AFCEE approval of the scientific report, ES will complete the full-scale conceptual design of the bioventing system and will submit this design, along with the final pilot test report, in the final technical report (referred to as data item A005 in the statement of work).

8.0 POINTS OF CONTACT

Capt. Erin Manning
7 CES/CEV
Carswell Air Force Base
817/782-6250

Chris Hobbins
AFCEE/ESB
Brooks AFB, TX 78235
210/536-5261

David Highland/Brian Vanderglas
Engineering-Science, Inc.
7800 Shoal Creek Blvd., Suite 222W
Austin, TX 78757

9.0 REFERENCES

ES, 1992. Field sampling plan for AFCEE bioventing. Engineering-Science, Inc., Denver, Colorado.

Hinchee et al., 1992. Test plan and technical protocol for a field treatability test for bioventing, by R.E. Hinchee, S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. January.

Radian Corporation, 1991a. Remedial investigation for the East Area, draft report for Carswell Air Force Base, Texas. Austin, Texas, April 1991.

Radian Corporation, 1991b. Feasibility study of the East Area, final report for Carswell Air Force Base, Texas. Austin, Texas, October 1991.

Appendix B

Interim Pilot Test Report

Report on Interim Pilot Test Results
Site ST14, Fuel Loading Area
Carswell AFB, Texas

Contract F41624-92-D-8036

Prepared for

Air Force Center for Environmental Excellence
Brooks AFB, Texas

Prepared by

Engineering-Science, Inc.
Austin, Texas

August 1993

CONTENTS

FIGURES

TABLES

DRAFT

REPORT ON INTERIM PILOT TEST RESULTS
SITE ST14, FUEL LOADING AREA
CARSWELL AFB, TEXAS

Initial bioventing pilot tests were completed at site ST14 at Carswell Air Force Base (AFB), Texas, during the period of May 24, 1993 through June 17, 1993. The purpose of this report is to describe the results of the initial pilot tests at site ST14 and to make specific recommendations regarding extended testing to determine the long-term impact of bioventing on onsite contaminants. This test was performed concurrently with a site characterization investigation to delineate the extent of contaminated soils at the site. Descriptions of the history, geology, and contamination at each site are contained in the bioventing pilot test work plan.

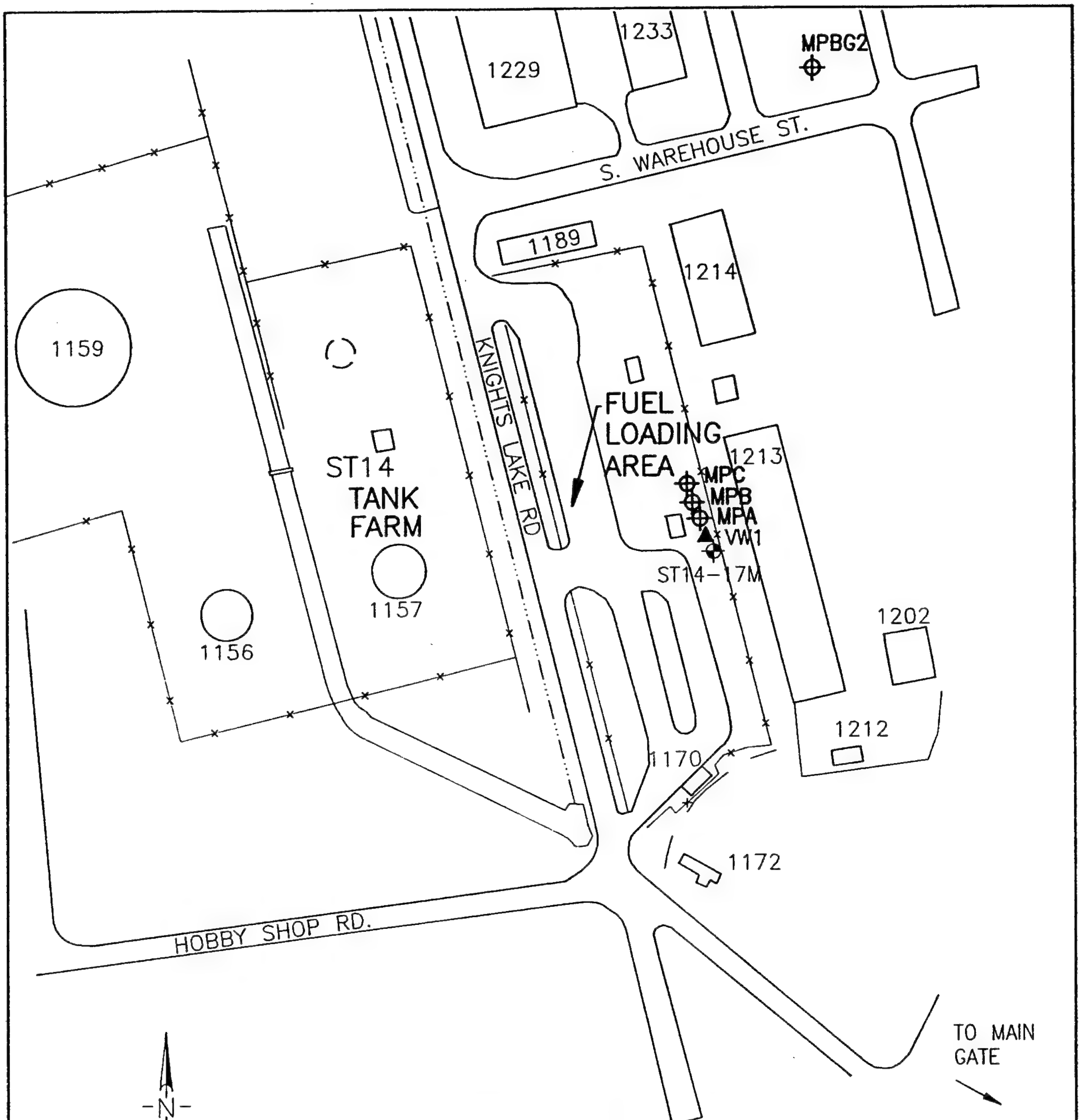
PILOT TEST DESIGN AND CONSTRUCTION

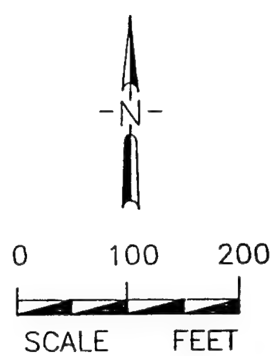
Installation of an air injection vent well (VW) and three vapor monitoring points (MPs) began on May 24, 1993, and was completed on May 27, 1993. A background monitoring point (MPBG2) was constructed on June 15, 1993, during site characterization studies at the site. Drilling services were provided by Profile Field Services, Inc., of Austin, Texas. Well installation and soil sampling were directed by Brian Vanderglas, the Engineering-Science, Inc. (ES), site manager, and Marc Harder, the ES site geologist. The following sections describe the final design and installation of the bioventing pilot system at this site.

One VW, three MPs (MPA, MPB, and MPC), a background monitoring point (MPBG2), and a pilot blower unit were installed at the site. Figures 1 and 2 depict the locations of the VW and MPs. The locations of the VW and MPs were changed from those in the work plan because of potential hazards from nearby underground utilities. Figure 3 shows general hydrogeologic cross section of the VW and MPs.

AIR INJECTION VENT WELL

The air injection VW was constructed following procedures described in the Air Force Center for Environmental Excellence (AFCEE) bioventing protocol document (Hinchee et al., 1992). Figure 4 shows construction details for the VW. The VW was installed in predominantly clayey soils where hydrocarbon contamination was indicated at all sampling depths. These soils had some gravel with increasing sand content as depth in the borehole increased. Groundwater was





LEGEND

ST14-02	MONITOR WELL
VW1	VENT WELL
MPA	MONITOR POINT

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DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93 FIGURE 1 SITE ST14 LAYOUT		
DRAWN BY:			
REVIEWED BY: B.R. VANDERGLAS			
SUBMITTED BY: J.D. HIGHLAND			
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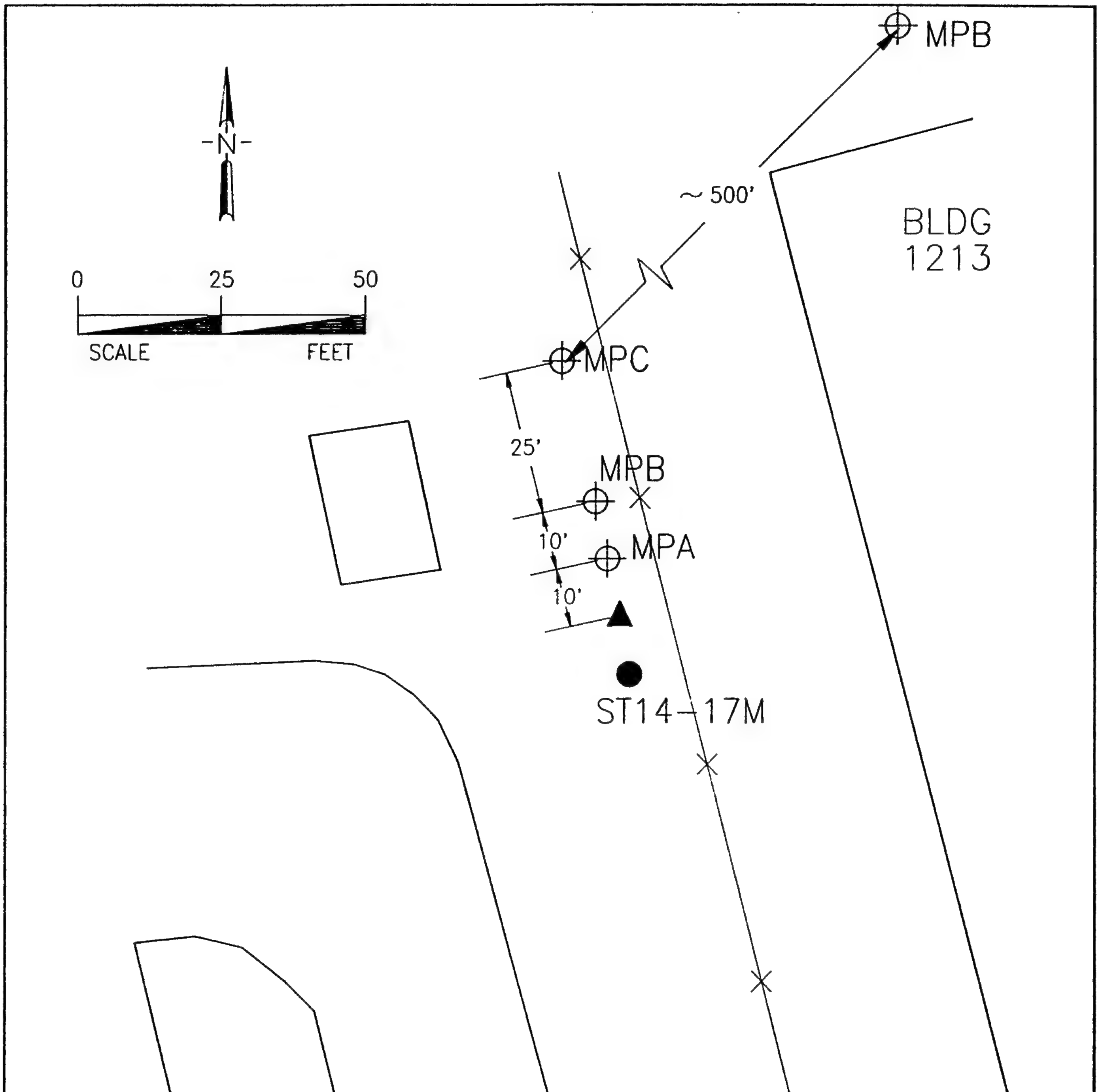

LEGEND

▲ PROPOSED CENTRAL VENT WELL (AIR INJECTION)

ST14-17M ● EXISTING MONITORING WELLS

MPC ⊕ PROPOSED VAPOR MONITORING POINT

—×—×— FENCE

1213 BUILDING

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DRAWN BY:	FIGURE 2 AS-BUILT SITE PLAN
REVIEWED BY: B.R. VANDERGLAS	
SUBMITTED BY: J.D. HIGHLAND	SITE ST14

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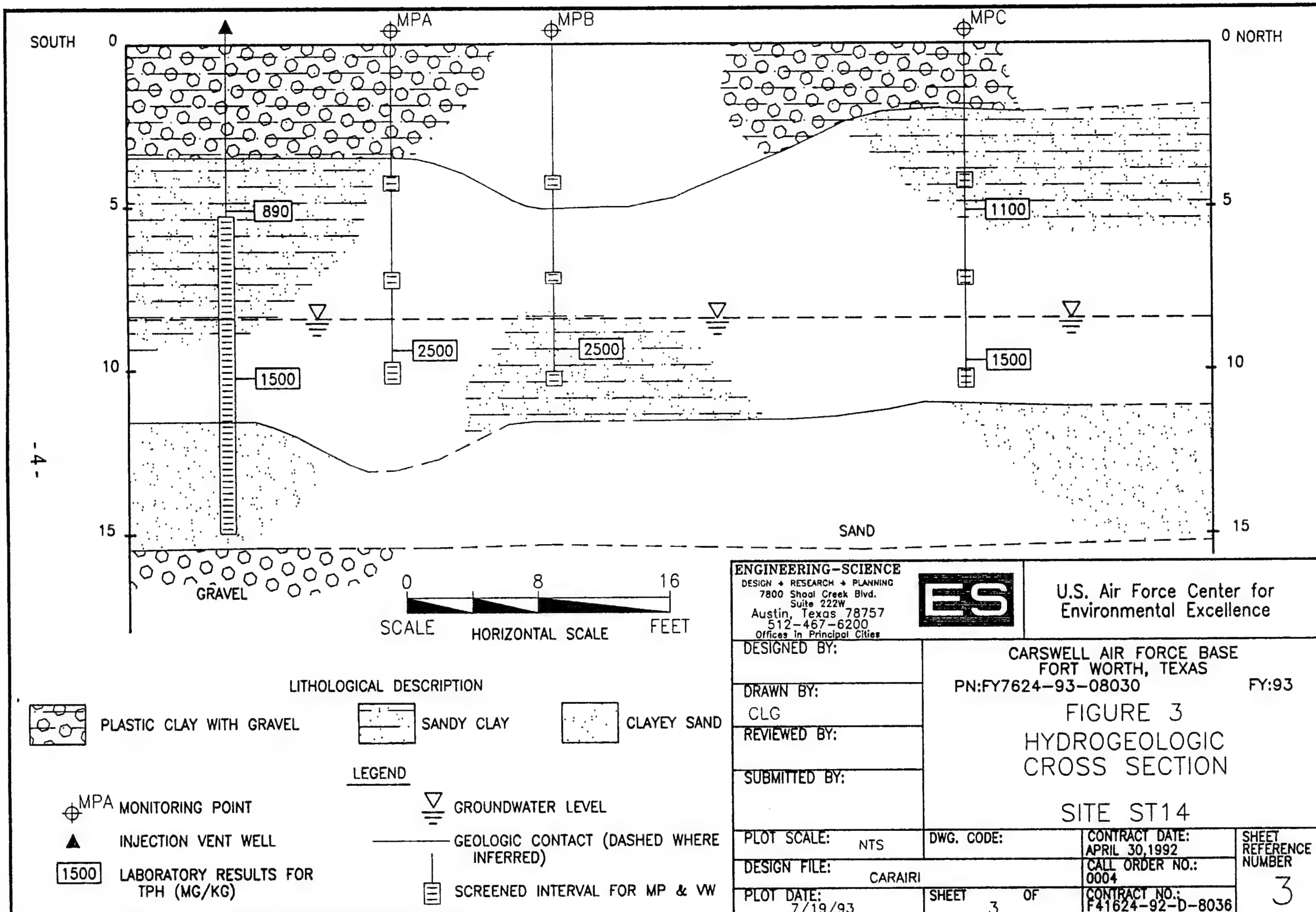
SOUTH
NORTH
0
5
10
15
MPA
MPB
MPC
890
1500
2500
2500
1100
1500
SAND
GRAVEL
0
8
16
SCALE
HORIZONTAL SCALE
FEET
LITHOLOGICAL DESCRIPTION
PLASTIC CLAY WITH GRAVEL
SANDY CLAY
CLAYEY SAND
LEGEND
MPA MONITORING POINT
INJECTION VENT WELL
1500 LABORATORY RESULTS FOR TPH (MG/KG)
GROUNDWATER LEVEL
GEOLOGIC CONTACT (DASHED WHERE INFERRED)
SCREENED INTERVAL FOR MP & VW
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FY:93
FIGURE 3
HYDROGEOLOGIC CROSS SECTION
SITE ST14
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CONTRACT DATE: APRIL 30,1992
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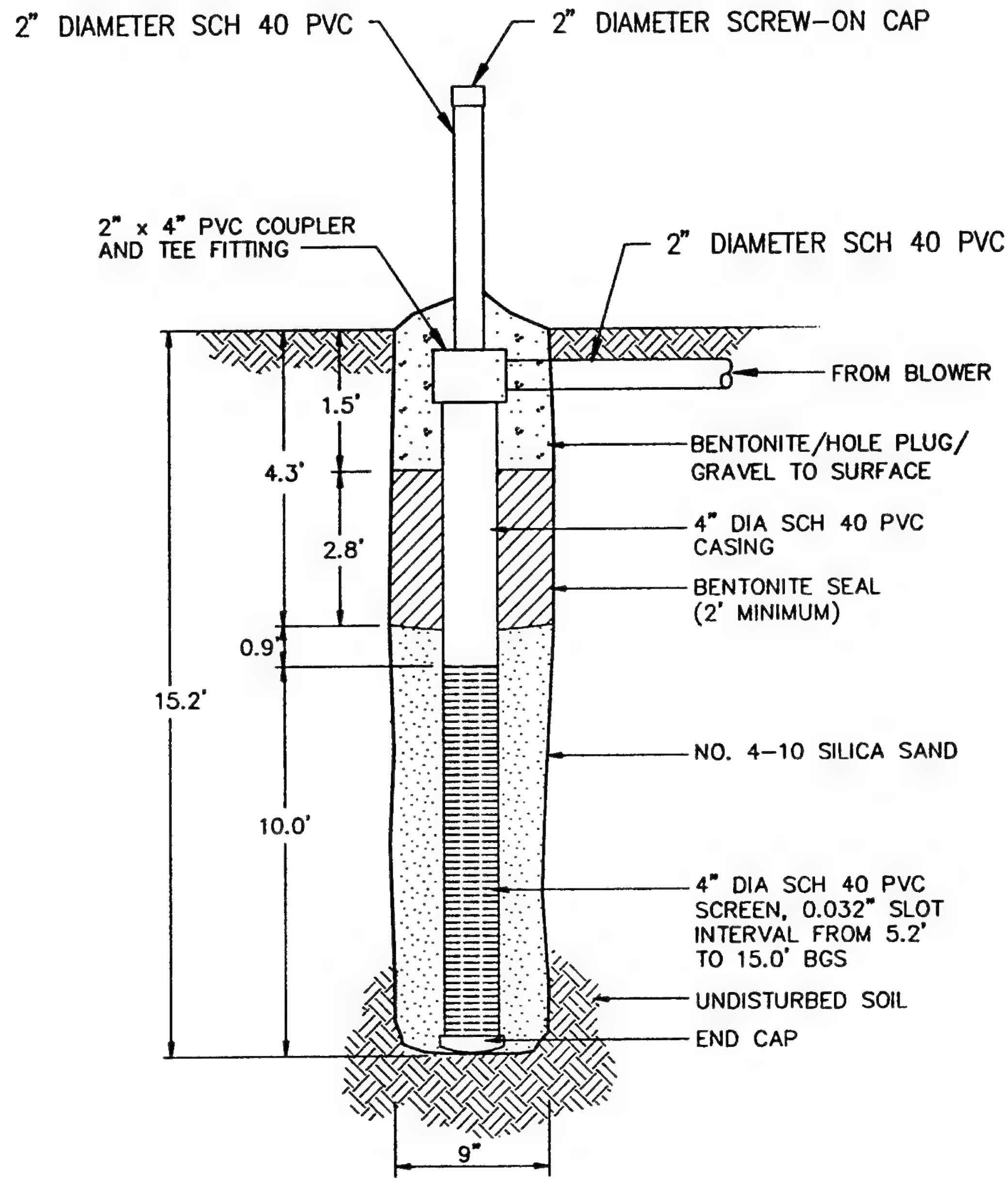

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DRAWN BY:	FIGURE 4 AS-BUILT INJECTION VENT WELL CONSTRUCTION DETAIL SITE ST14
REVIEWED BY: B.R. VANDERGLAS	
SUBMITTED BY: J.D. HIGHLAND	

PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 4
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PLOT DATE: 7/15/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	

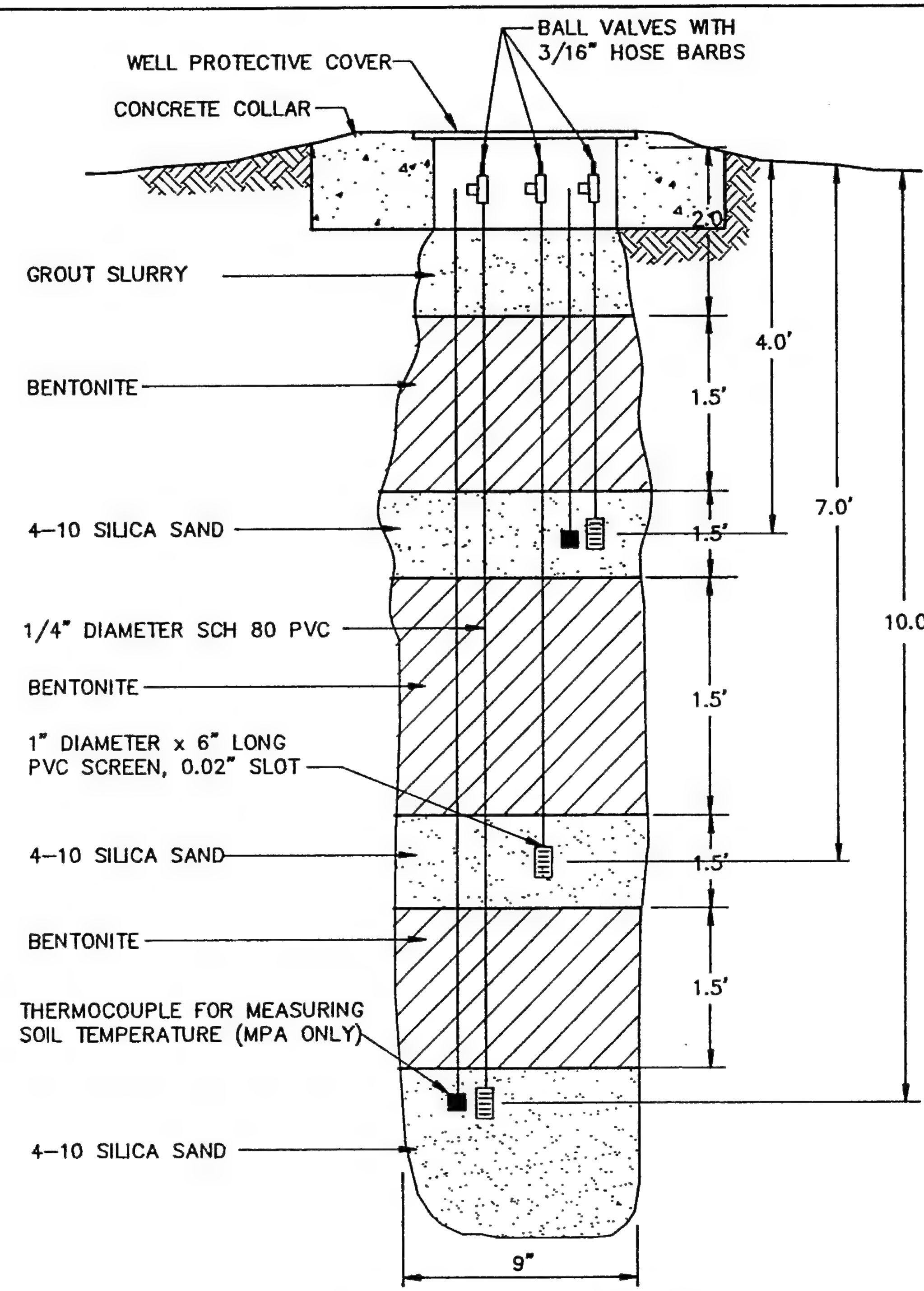
encountered at approximately 11.0 feet below ground surface (bgs) in each borehole. The static water level rose to 8.5 feet bgs in the boreholes during well completion. The VW was constructed using 4-inch-diameter, schedule 40 polyvinyl chloride (PVC) casing, with 10 feet of 0.04-inch slotted PVC screen installed from 5 to 15 feet bgs. The annular space between the well casing and borehole was filled with 4-10 silica sand from the bottom of the borehole to approximately 1 foot above the well screen. Approximately 2.8 feet of ¼-inch bentonite pellets was placed above the sand and hydrated in place. After the *in situ* respiration testing was completed the well casing was cut off approximately 12 inches below the surface, and the casing was connected to a PVC pipe coupler to reduce the pipe from 4-inch diameter to 2-inch diameter. The coupler is a tee fitting that enables the vent well to extend vertically above the surface in the event access to the cased well is required. A second 2-inch-diameter pipe extends from the tee fitting horizontally beneath the surface to the blower. This pipe slopes slightly toward the vent well to allow drainage of moisture in the pipe into the well and away from the blower.

Monitoring Points

At Site ST14, the MP screens were installed at 4.0-, 7.0-, and 10.0-foot depths. The three MPs (MPA, MPB, and MPC) and the background MP (MPBG2) were constructed as shown in Figure 5. Each MP monitoring interval was constructed using approximately a 6-inch section of 1-inch-diameter PVC well screen and a 0.25-inch-diameter schedule 80 PVC riser pipe extending to near the ground surface. At the top of each riser, a ball valves and a $^{3}/_{16}$-inch hose bib were installed. The screen, PVC riser, and ball valve were joined together using a solvent-free epoxy glue. The top of each MP was completed with a flush-mounted metal well protector set in a concrete base. Thermocouples were installed at the 4- and 10-foot depths at MPA to measure soil temperature variations. The background MP (MPBG2) is located near building 1237 South Warehouse Road and 15 feet east of West Warehouse Road, approximately 500 feet north-northeast from the injection vent well.

Blower Unit

During the initial pilot test, a portable 3-horsepower Roots™ 22U-RAI positive-displacement blower unit was used. A 1-horsepower Gast™ R4110-50 regenerative blower unit was installed at site ST14 and connected to the air injection VW for the extended pilot test. The fixed unit is energized by 240-volt, single-phase, 30-amp line power from a newly installed underground power line and aboveground breaker attached to building 1213. The power is provided by the base. The configuration, instrumentation, and specifications for this blower system are shown on Figure 6. The blower is currently transporting air at a flow rate of approximately 15 actual cubic feet per minute (acfm) for the extended pilot test. A portion of this flow is bled off through the gate valve. After blower installation and startup, ES engineers provided base personnel with an operation and maintenance (O&M) manual, including maintenance instructions, equipment specifications, and monitoring forms. A copy of the O&M instructions is in appendix A.



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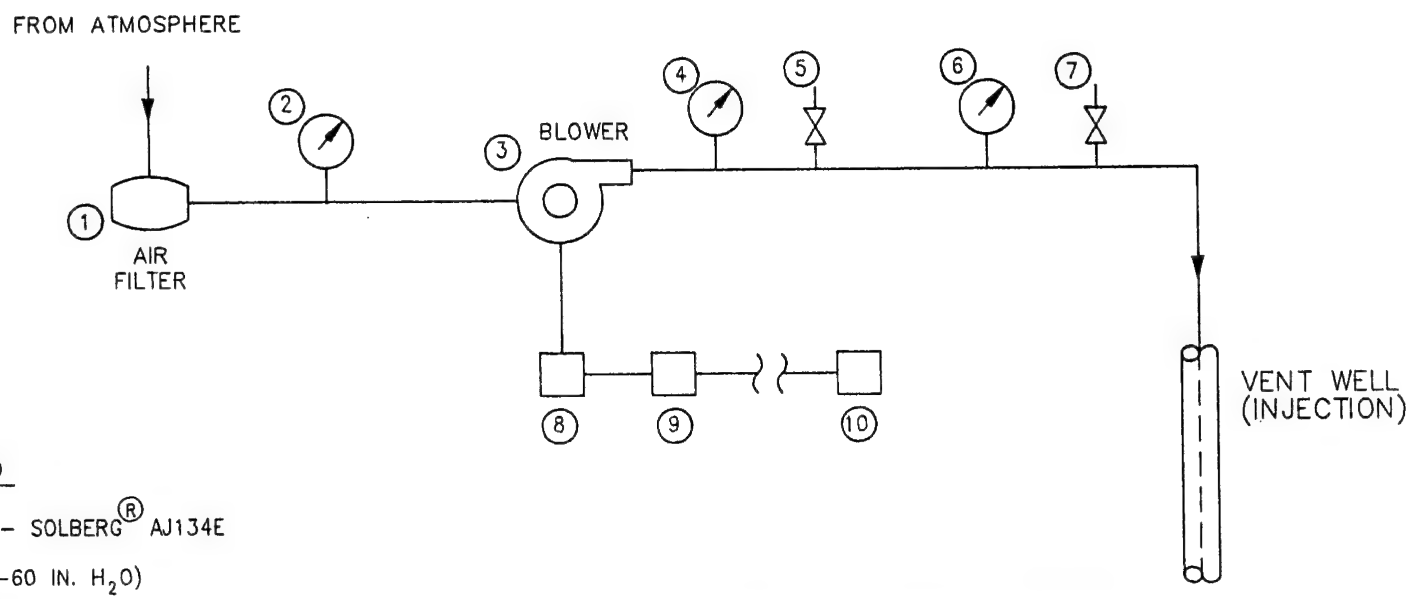
DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93		
DRAWN BY:	FIGURE 5 AS-BUILT MONITORING POINT CONSTRUCTION DETAIL SITE ST14		
REVIEWED BY: B.R. VANDERGLAS			
SUBMITTED BY: J.D. HIGHLAND			
PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 5
DESIGN FILE: DETLCARS		CALL ORDER NO.: 0004	
PLOT DATE: 7/15/93	SHEET 1 OF 1	CONTRACT NO.: F41624-92-D-8036	



LEGEND

1. INLET AIR FILTER – SOLBERG® AJ134E
2. VACUUM GAUGE (0–60 IN. H_2O)
3. BLOWER – GAST® 1HP R4110–50
4. PRESSURE GAUGE (0–100 IN H_2O)
5. AUTOMATIC PRESSURE RELIEF VALVE, SET TO RELEASE AT 58 IN H_2O PRESSURE
6. TEMPERATURE GAUGE (0–250°F)
7. MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" GATE
8. STARTER – FURNAS® 14CSD33DA NEMA 3, NO START/STOP, OVERLOAD SET AT 6 AMPS
9. DISCONNECT SWITCH – 240V/SINGLE PHASE/30 AMP, FUSED DISCONNECT (GENERAL DUTY)
10. BREAKER BOX – 30 AMP

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REVIEWED BY:
SUBMITTED BY:

CARSWELL AIR FORCE BASE
FORT WORTH, TEXAS
PN:FY7624-93-08030 FY:93

FIGURE 6
AS-BUILT BLOWER SYSTEM FOR AIR INJECTION

SITE ST14

PLOT SCALE: NTS	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER
DESIGN FILE: CARAIRI		CALL ORDER NO.: 0004	6
PLOT DATE: 7/16/93	SHEET 6 OF	CONTRACT NO.: F41624-92-D-8036	

PILOT TEST SOIL AND SOIL GAS SAMPLING RESULTS

Sampling Results

Soils at this site consist primarily of highly plastic clays with some interbedded gravel and silt near the surface. Sand content in soils generally increase with depth at the site, and soils are predominantly sands and gravels at approximately 11.5 to 12 feet and below. Groundwater was encountered at a depth of approximately 11.5 feet bgs in the VW, but the static water level rose to approximately 8.5 feet bgs in the open borehole. A thin film of oily product was observed on top of the water table in all the boreholes for VW1, MPA, MPB, and MPC. More detailed hydrogeologic information regarding site ST14 can be found in the hydrogeologic cross section (Figure 3) and the geologic boring logs (appendix B).

Contaminated soils were identified based on visual appearance, odor, and results of total hydrocarbons analyzer (Porta FID II, model PFII/7788 from Heathtech) field screening for volatile organic compounds (VOCs). Heavily contaminated soils were encountered approximately 3 to 12 feet bgs in the VW and all MP boreholes. Contamination concentrations generally increased with depth.

Soil samples for laboratory analysis were collected continuously using split core barrel samplers. Soil samples were screened for VOCs using the flame ionization detector (FID) to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected form MPA and MPB at depths bgs of 9 to 10 feet bgs, from the VW at depths of 5 to 6 feet, and 10 to 11 feet, from MPC at depths of 6 to 7 feet, and from background monitoring point (MPBG2) at 10 to 10.5 feet.

Soil gas samples were collected from the completed VW and at 4 feet bgs from MPA, and at 7 feet bgs at MPC. Soil gas samples were collected using 3-liter Tedlar™ bags and vacuum chambers. After the samples were collected with Tedlar™ bags, they were transferred to 1-liter SUMMA™ canisters and shipped to the air testing laboratory, Air Toxics Ltd.

Soil samples were picked up every other day by a courier representing NDRC Laboratories. NDRC Laboratories conducted chemical and physical analysis on the soil samples. One soil sample from each boring was analyzed for total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethyl benzene and xylenes (BTEX); iron; alkalinity; total Kjeldahl nitrogen (TKN); and several physical parameters (see Table 1). In boreholes in which two samples were collected (MPC and VW1), the sample collected nearest the surface was analyzed only for TRPH and BTEX. Soil gas samples were shipped via Federal Express™ to Air Toxics Ltd. in Rancho Cordova, California, for total volatile hydrocarbon (TVH) and BTEX analysis. The results of all of these analyses are in Table 1. Chain-of-custody forms are provided in appendix C.

Exceptions to Test Protocol Procedures

Procedures described in the protocol document (Hinchee et al., 1992) were used to complete the pilot test at site ST14, with the following exception. An FID

Table 1
Site ST14
Soil and Gas Analytical Results
Carswell AFB, Texas

Analyte (units)*	Sample Location - Depth (feet below ground surface)							
	VW1:10-11	VW1:5-6	MPA:9-10	MPB:9-10	MPC:6-7	MPC:10-11	MPBG2:10	MPA:4
Soil hydrocarbons:								
TRPH (mg/kg)	1,500	890	2,500	2,500	1,100	1,500	47	NT
Benzene (mg/kg)	.27	0.41	1.8	2.8	<.5	<0.2	<.002	NT
Toluene (mg/kg)	.53	0.58	3.7	4.1	2	10	<.002	NT
Ethyl benzene (mg/kg)	1.40	0.79	5.3	7	3.7	2.6	<.002	NT
Xylenes (mg/kg)	8.80	4.20	36	26	24	17	<.002	NT
Soil gas hydrocarbons:								
TVH (ppmv)	NT**	23,000	NT	NT	28,000	NT	NT	21,000
Benzene (ppmv)	NT	ND†	NT	NT	ND	NT	NT	ND
Toluene (ppmv)	NT	ND	NT	NT	ND	NT	NT	ND
Ethyl benzene (ppmv)	NT	6.4	NT	NT	7.9	NT	NT	4.4
Xylenes (ppmv)	NT	19	NT	NT	21	NT	NT	11.0
Soil inorganics:								
Phosphorus (mg/kg)	97.2	NT	114	96.2	NT	73.1	85.8	NT
Alkanlinity (mg/kg as $CaCo_3$)	350	NT	350	450	NT	250	1,550	NT
TKN (mg/kg)	350	NT	280	224	NT	420	238	NT
Soil physical parameters:								
Moisture (% wt)	15.3	NT	25.3	23	NT	16.3	15.7	NT
pH (units)	8.9	NT	8.6	9	NT	8.9	8.3	NT
Gravel (% >2.0 mm)	<0.1	NT	<0.1	<0.1	NT	<0.1	<0.1	NT
Sand (% 0.75-2.0 mm)	20.5	NT	7.5	6	NT	38.6	24.5	NT
Silt (% .05-0.75 mm)	60.6	NT	65.8	60.4	NT	49.5	57	NT
Clay (% <0.005 mm)	18.9	NT	26.8	33.6	NT	11.9	18.5	NT
Soil temperature, 6-9-93 (°F)	NT	NT	64.3	NT	NT	NT	NT	69.8
Soil temperature, 6-15-93 (°F)	NT	NT	64.9	NT	NT	NT	NT	72.8

* TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram; TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen; °F = degrees Fahrenheit.

** NT = not tested at this location.

† ND = not detected.

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rather than a GasTech® hydrocarbon analyzer was used to field screen the soil samples and monitor the breathing zone during drilling and soil sampling activities. Also, more than one sample was collected from some borehole since this pilot test is part of a site characterization investigation to determine the extent of soil contamination at the site.

PILOT TEST RESULTS

Initial Soil Gas Chemistry

Before air injection began, all MPs and the VW were purged, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers, as described in the technical protocol document (Hinchee et al., 1992). Table 2 summarizes the initial soil gas chemistry at site ST14. The results strongly indicate that biological fuel degradation has depleted the oxygen supply in the vadose zone soils. Three of the six sampling points at site ST14 were under anaerobic conditions, and soil gas at the remaining three sampling points contained oxygen at low levels ranging from 0.8 percent to 3.8 percent. In contrast, the background MP, installed in uncontaminated soil approximately 500 feet northeast of the site, contained oxygen at levels ranging from 13.2 percent (7 feet depth) to 20.6 percent (4 foot depth). Carbon dioxide was present at elevated concentrations, ranging from 9.8 to 11.0 percent, in all initial soil gas samples collected at site ST14. The background MP carbon dioxide levels ranged from 9.0 to 0.05 percent. The ambient oxygen and carbon dioxide levels of MPGB2 at 4 feet bgs suggest that short-circuiting between this interval and the surface has occurred, which indicates an inadequate seal between the surface and this MP depth. High hydrocarbon concentrations measured in the initial soil gas testing possibly indicate the volatilization of fuel from the free product layer into the pore space of the vadose zone soils at site ST14.

Air Permeability

An air permeability test was conducted at site ST14 according to protocol document procedures. Air was injected into the VW for approximately 3.5 hours at a rate of approximately 28 acfm and an average pressure of approximately 7 pounds per square inch (psi). The pressure response at each MP is listed in Table 3. The pressure measured at all MPs achieved steady-state conditions within 45 minutes. Since more than 10 minutes was required to achieve steady state in all of the monitoring points, the dynamic method of determining soil gas permeability was selected. As discussed in the technical protocol document (Hinchee et al., 1992), the dynamic method of determining soil gas permeability that is coded in the HyperVentilate™ model is appropriate for soils which reach steady state in more than approximately 10 minutes. Two depths from both MPA (10 feet from injection point, VW1) and MPC (45 feet from injection point, VW1) were used to calculate relative air permeability of the soils. No response was observed in the 4-foot interval of MPB (20 feet from injection point, VW1). This may be due to the moist, highly plastic, and tightly consolidated clayey soils in which the monitoring point was constructed.

Table 2
Site ST14
Initial Soil Gas Chemistry
Carswell AFB, Texas

MP	Depth	O_2(%)	CO_2(%)	Field TVH* (ppmv)	Lab TVH (ppmv)	Lab TRPH (mg/kg)
VW	5-8.5	3.8	10.1	294,000	23,000	890
A	4	0.8	10.4	546,000	21,000	NT**
A	7	0.0	10.8	<200,000	NT	NT
A	10	NS†	NS	NS	NS	2,500
B	4	0.0	11.0	290,000	NT	NT
B	7	NS	NS	NS	NT	NT
B	10	NS	NS	NS	NS	2,500
C	4	0.0	10.3	200,000	NT	NT
C	7	2.2	9.8	212,000	28,000	1,100
C	10	NS	NS	NS	NS	1,500
BG2	4	20.6	0.05	NT	NT	
BG2	7	13.2	9.0	NT	NT	
BG2	10	NS	NS	NS	NS	

* Estimated value using dilution method.
** NT = not tested at this location.
† NS = not sampled due to saturated moisture conditions at MP depth interval.

Table 3
Site ST14
Pressure Response During the Air Permeability Test
Carswell AFB, Texas

Elapsed Time (min)	Location: Depth (ft):	Pressure Response in MP (inches of water) MPA 4	MPA 7	MPB 4	MPC 4	MPC 7
0*		-0.05**	0.00	-0.10	0.20	0.20
0.5		0.00	0.85	-0.30	0.15	0.20
1.0		0.10	2.20	-0.30	0.15	0.20
2.0		0.45	3.50	-0.35	0.30	0.25
3.0		0.75	4.55	-0.35	0.20	0.25
4.0		1.00	6.00	-0.40	0.55	0.35
5.0		1.40	7.20	-0.50	0.80	0.70
6.0		2.30	8.40	-0.50	1.05	1.10
7.0		--†	--	-0.50	1.40	1.35
8.0		2.75	9.40	--	1.70	1.70
9.0		--	--	--	2.10	2.10
10.0		3.90	>10.00	--	2.25	2.25
12.0		4.85	11.00	0.00	2.65	2.60
22.0		8.00	11.70	-0.30	3.10	3.05
37.0		9.70	12.20	-0.40	3.50	3.50
54.0		11.70	12.80	--	--	--
92.0		12.20	13.00	+0.25	3.60	3.60
120.0		12.10	13.10	+0.25	3.60	3.65
152.0		12.10	13.10	+0.40	3.60	3.65

* Pressure readings taken prior to initiating field test (blower start up).
** Negative sign indicates vacuum pressure at MP.
† Denotes no reading taken at this time.

A constant injection flow rate of 28 afcm and a screened interval thickness of 3.5 feet (5 feet bgs top of screen to 8.5 feet bgs to water level in vent well) were used to calculate, a soil gas permeability of 26.4 and 30.8 darcy for the 10-foot radial distance at 4 and 7 feet, respectively. The soil gas permeability for the 45-foot radial distance at 4 and 7 feet is 94.2 and 93.4 darcy, respectively. An average of 61.2 darcy was calculated for this site. The HyperVentilate® cards depicting these calculations are in appendix D. This value is approximately one order of magnitude higher than would be expected for the predominantly clayey soils at the site; however, the presence of gravel throughout the soil profile and increasing sand content with depth appears to have increased the average permeability at this site. A radius of pressure influence of at least 45 feet was observed at all depths. Given the steady-state pressure responses from 10 and 45 feet from the vent well, and assuming a linear relationship, the estimated radius of influence for this site at 28 acfm appears to be 60 feet.

Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at the given flow rate and VW screen configuration.

Table 4 describes the change in soil gas oxygen levels that occurred during the 3.5-hour air injection test at the site, and the air injection period which extended at a lower flow rate (24 acfm) for an additional 17 hours. The relatively brief (3.5 hours) air injection period at 28 acfm produced changes in soil gas oxygen levels at a distance of at least 45 feet from the central VW at both monitored depth intervals and in MPA and MPC and at the one monitored depth interval in MPB. Significant increases in the oxygen concentration were measured at each MP interval. Considering measured pressure response, which is an indicator of long-term oxygen transport, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 45 feet at all depths. Monitoring during the extended pilot test at this site will better define the effective treatment radius.

In Situ Respiration Rates

In situ respiration testing was performed at site ST14 according to protocol document procedures. Air was injected into the VW and MP screens MPA-4, MPA-7, MPB-4, MPC-4, and MPC-7 for 16 hours at a rate of approximately 1 acfm per screened interval to deliver oxygen to contaminated soils. At the end of the 16-hour period, air injection ceased, and changes in soil gas composition were monitored over time. Oxygen, TVH, and carbon dioxide were measured over a period of 72 hours following the air injection period. The observed rates of oxygen utilization were then used to estimate the aerobic fuel degradation rates at site ST14. Figures 7 through 11 present the results of *in situ* respiration testing at the site, and Table 5 is a summary of the observed oxygen utilization rates.

Table 4
Site ST14
Influence of Air Injection at Vent Well
on Monitoring Point Oxygen Levels
Carswell AFB, Texas

MP	Distance from VW (ft)	Depth (ft)	Initial O_2 (%)	O_2 (%)*	Final O_2 (%)**
A	10.0	4	3.2	18.0	19.4
A	10.0	7	0.0	17.9	20.4
A	10.0	10	NS†	NS	NS
B	20.0	4	0.0	12.3	17.7
B	20.0	7	NS	NS	NS
B	20.0	10	NS	NS	NS
C	45.0	4	0.0	1.3	11.1
C	45.0	7	0.0	2.0	12.7
C	45.0	10	NS	NS	NS

* Duration of air injection = 3.5 hours.
** Duration of air injection = 3.5 hours at 28 acfm, and 17 hours at 24 acfm.
† NS = not sampled due to water levels at 8.5 feet bgs.

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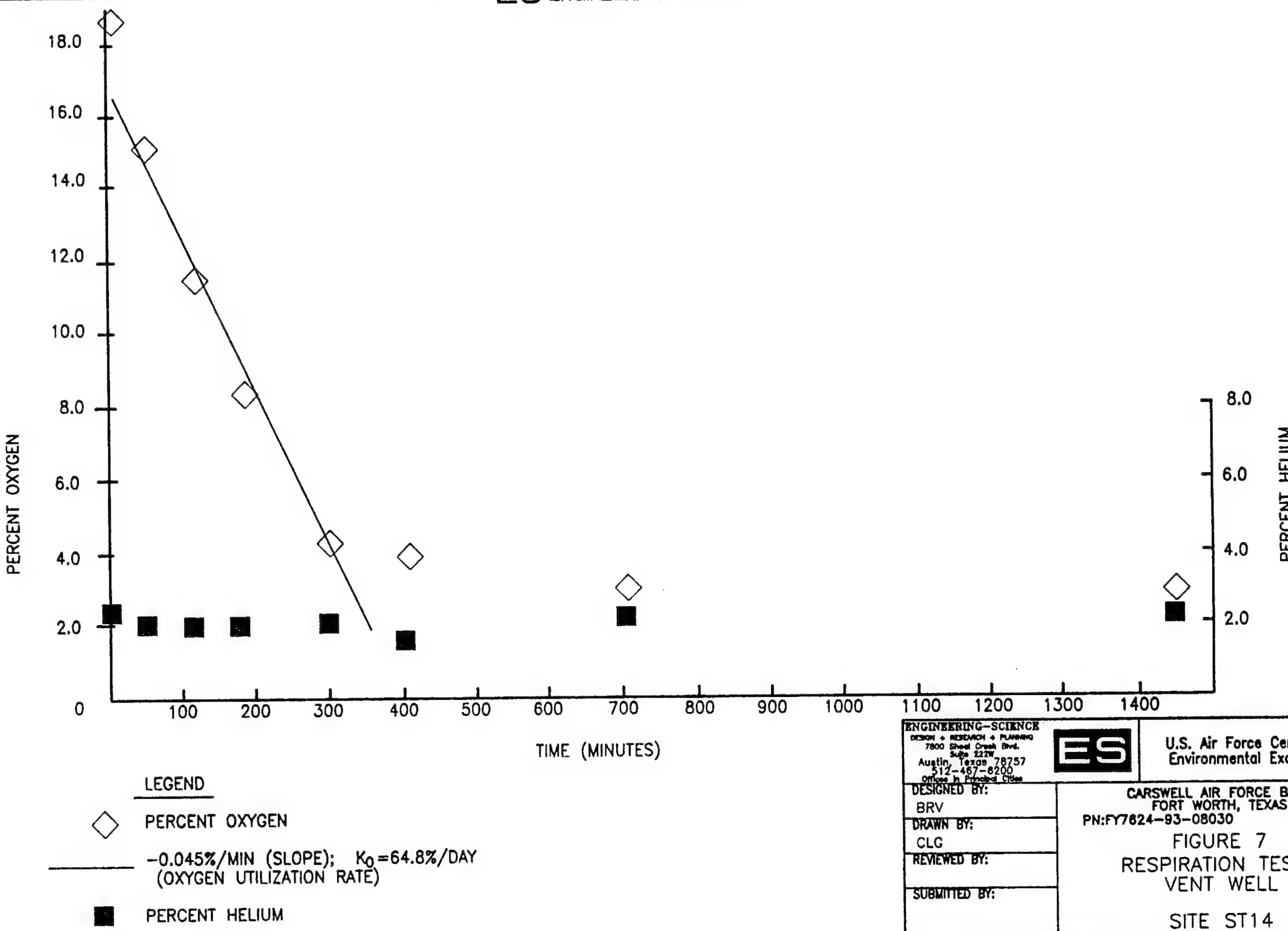

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DRAWN BY: CLG
REVIEWED BY:
SUBMITTED BY:

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FORT WORTH, TEXAS
PN:FY7624-93-08030 FY:93

FIGURE 7
RESPIRATION TEST
VENT WELL

SITE ST14

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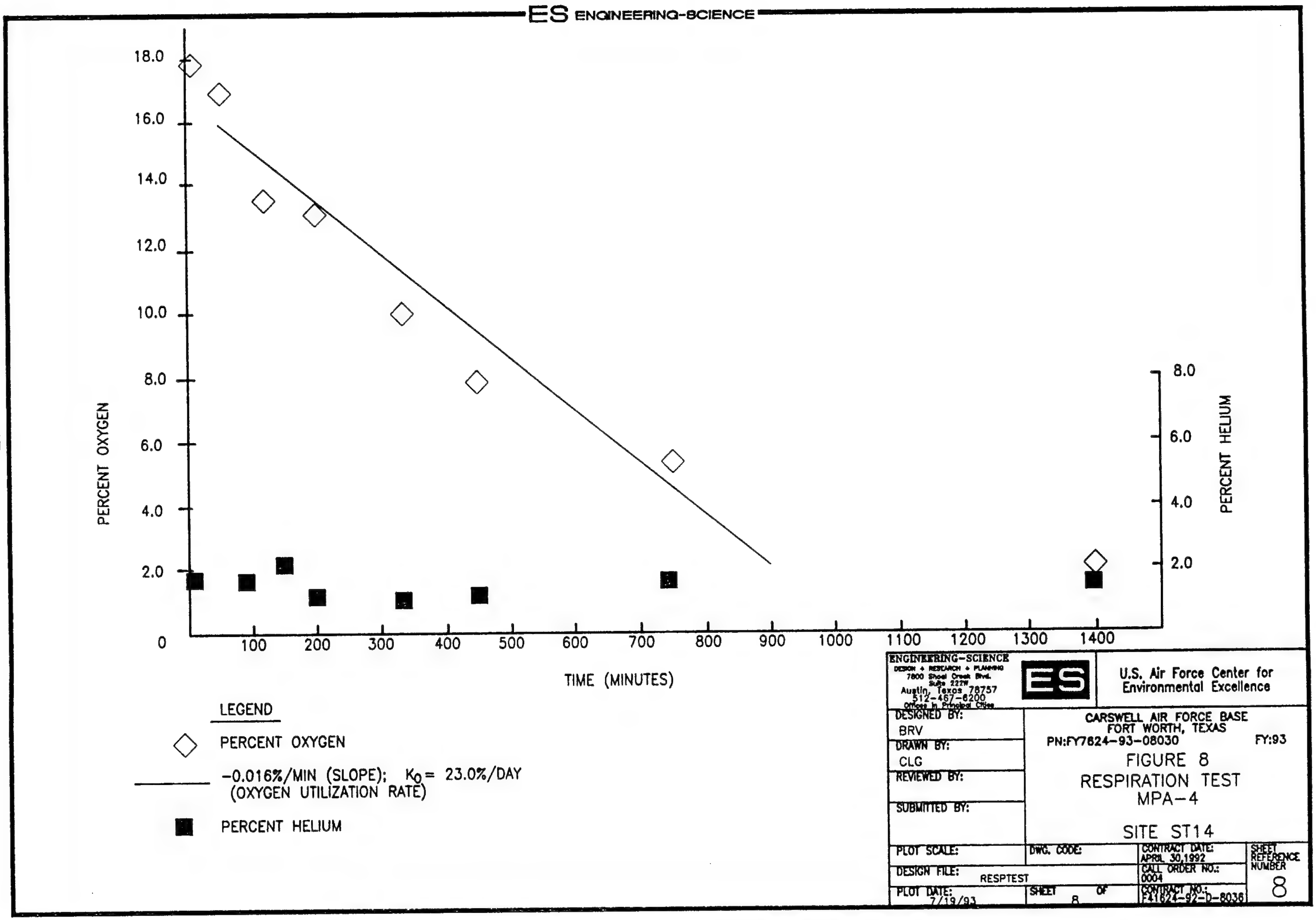
PLOT DATE: 7/19/93 | SHEET 7 OF | CONTRACT NO.: F41624-92-D-8036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PERCENT OXYGEN
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
TIME (MINUTES)
PERCENT HELIUM
8.0
6.0
4.0
2.0
LEGEND
PERCENT OXYGEN
-0.016%/MIN (SLOPE); K0= 23.0%/DAY
(OXYGEN UTILIZATION RATE)
PERCENT HELIUM
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FY:93
FIGURE 8
RESPIRATION TEST
MPA-4
SITE ST14
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CONTRACT DATE:
APRIL 30,1992
SHEET REFERENCE NUMBER
8
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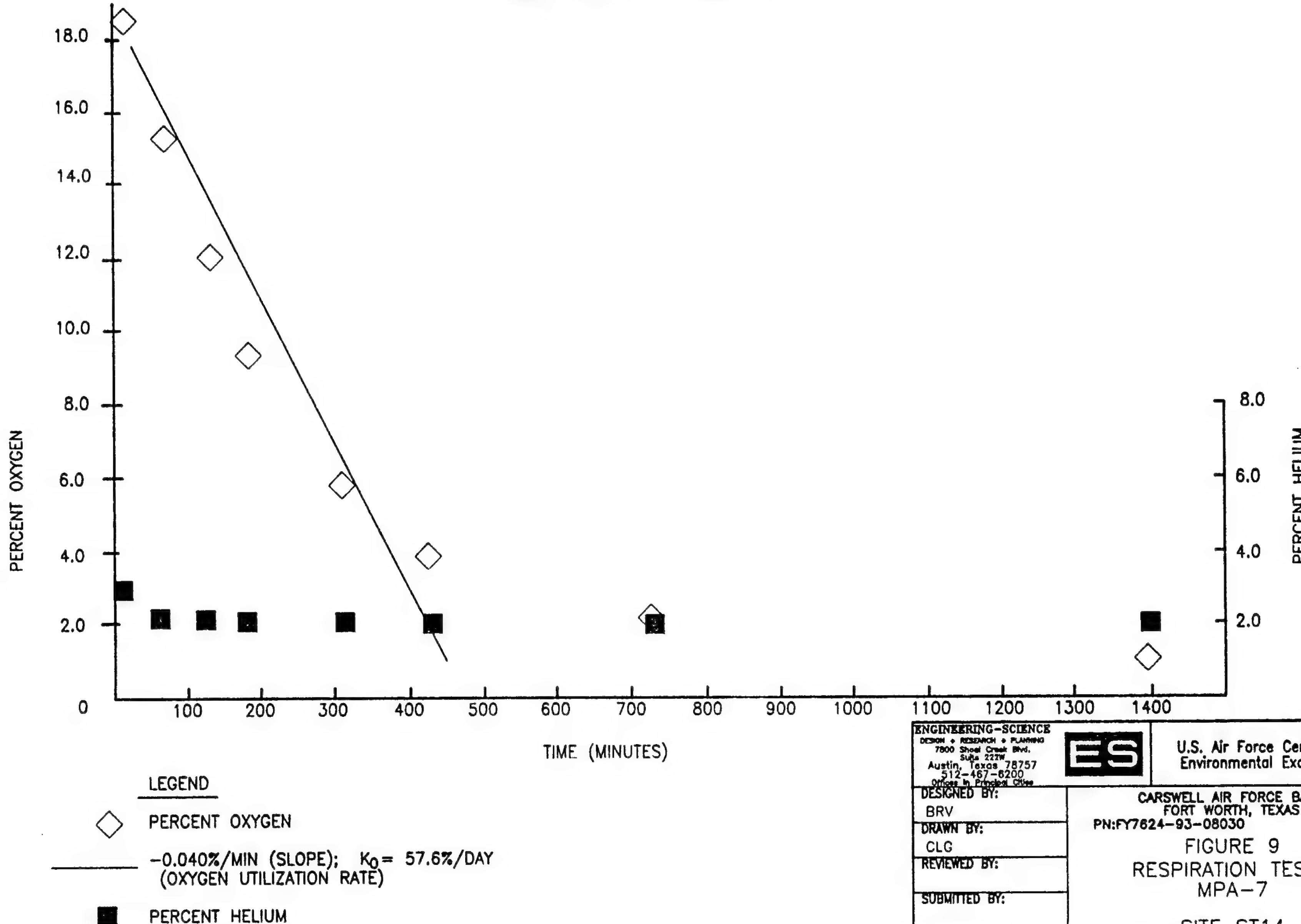

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FIGURE 9
RESPIRATION TEST
MPA-7

SITE ST14

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SUBMITTED BY:		
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DESIGN FILE: RESPTEST		CALL ORDER NO.: 0004
PLOT DATE: 7/19/93	SHEET 9 OF	CONTRACT NO.: F41624-92-D-8036

SHEET REFERENCE NUMBER 9

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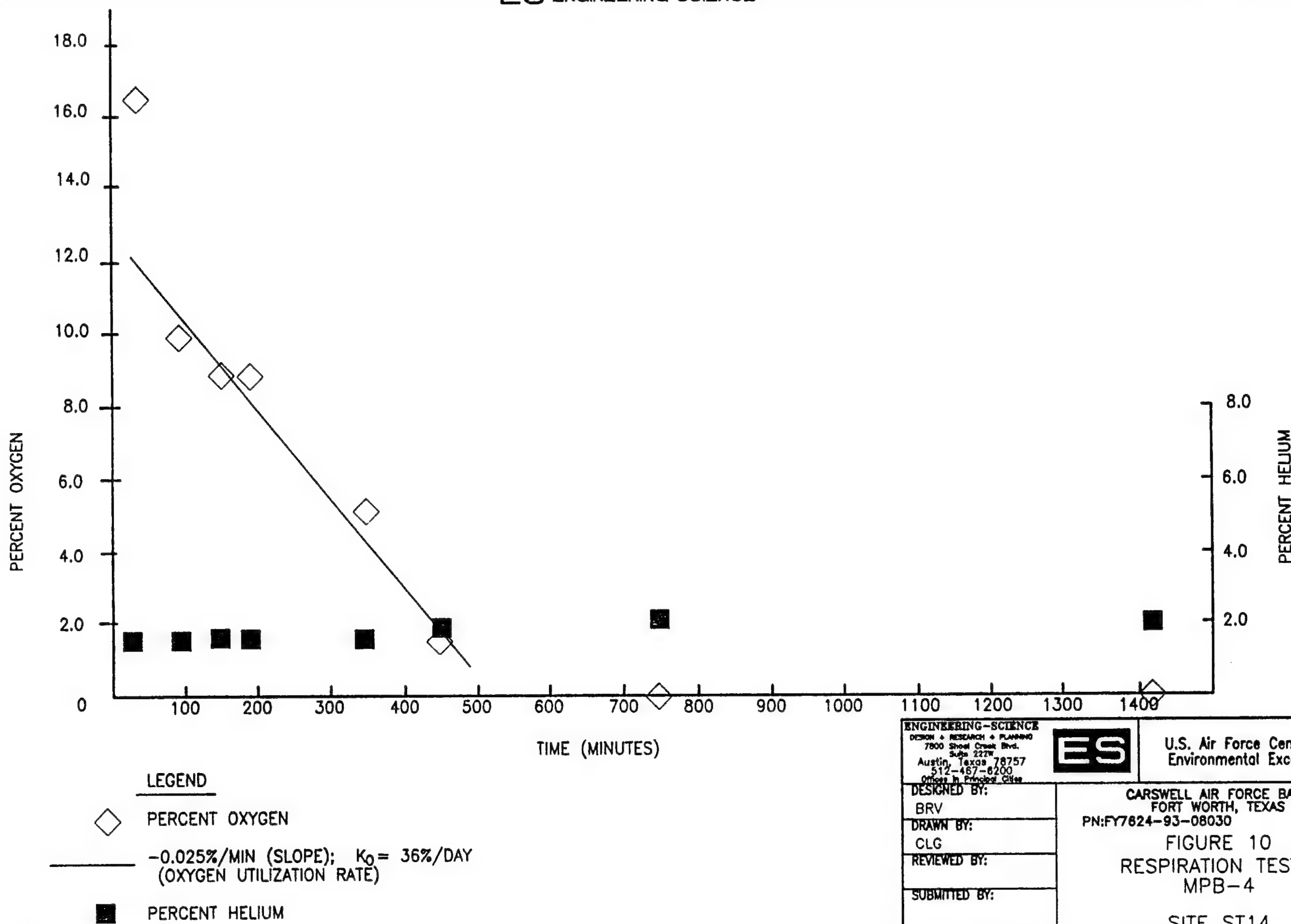

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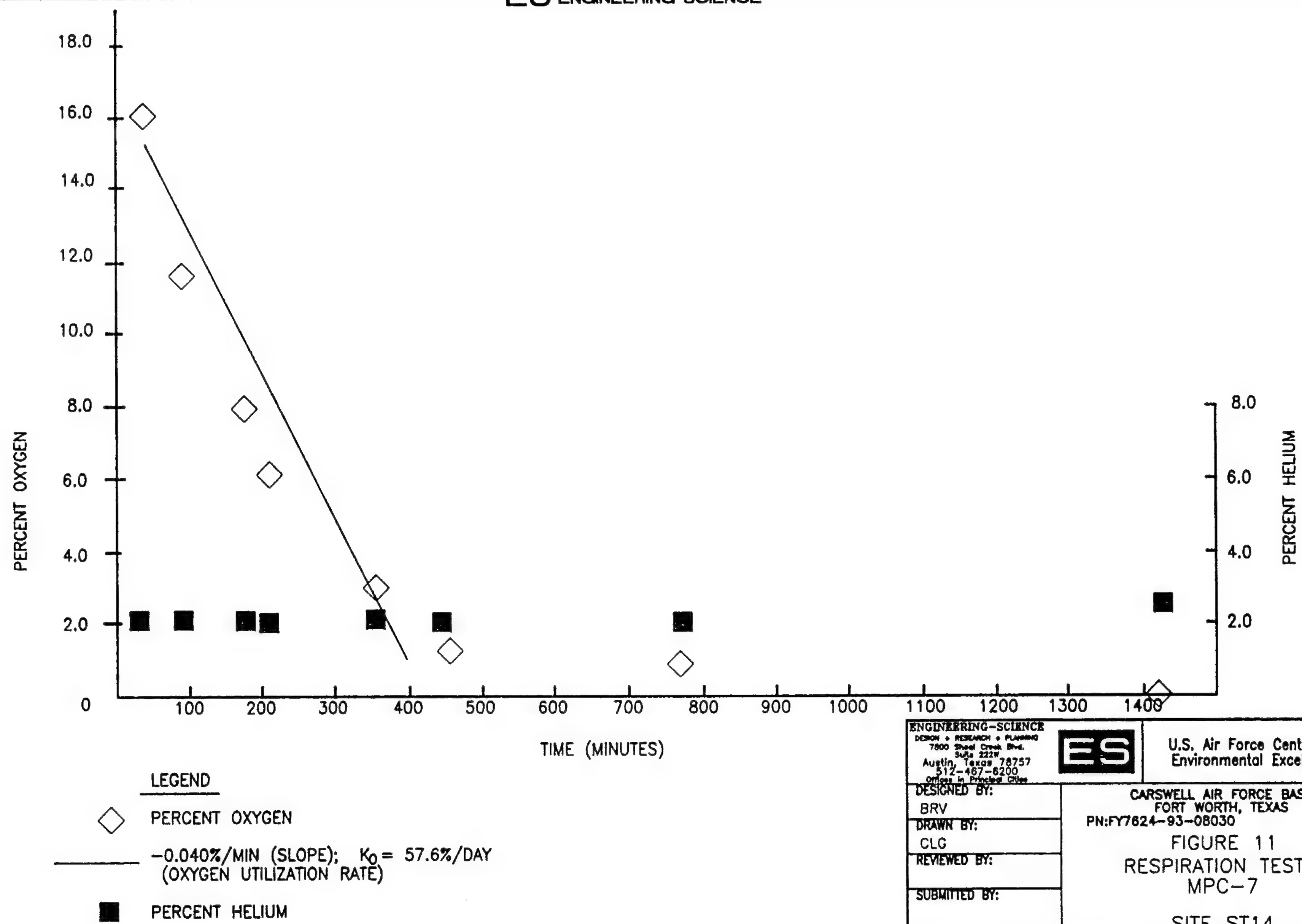
DESIGNED BY: BRV DRAWN BY: CLG REVIEWED BY: SUBMITTED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93 FIGURE 10 RESPIRATION TEST MPB-4 SITE ST14		
PLOT SCALE:	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER
DESIGN FILE: RESPTEST		CALL ORDER NO.: 0004	10
PLOT DATE: 7/19/93	SHEET 10 OF	CONTRACT NO.: F41624-92-D-8036	



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REVIEWED BY:

SUBMITTED BY:

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FIGURE 11
RESPIRATION TEST
MPC-7

SITE ST14

PLOT SCALE: | DWG. CODE: | CONTRACT DATE: APRIL 30,1992 | SHEET REFERENCE NUMBER

DESIGN FILE: RESPTEST | CALL ORDER NO.: 0004 | 11

PLOT DATE: 7/19/93 | SHEET 11 OF | CONTRACT NO.: F41624-92-D-8036

Table 5
Site ST14
Oxygen Utilization Rates
Carswell AFB, Texas

MP	O_2 Loss* (%)	Test Duration (min)	O_2 Utilization* Rate (% min)
VW	13.5	300	0.045
MPA-4	12.0	750	0.016
MPA-7	18.0	450	0.040
MPB-4	11.25	450	0.025
MPC-7	16.0	400	0.040

* Values based on linear regression (Figures 7 through 11).

An average 2.5-percent mixture of helium in air was injected during the 16-hour injection period into the screened intervals of all the tested MPs and the VW, and the loss of helium was measured for 72 hours following air injection. Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining if oxygen diffusion is responsible for a portion of the oxygen lost from each MP. Figures 7 through 11 also compare oxygen utilization and helium retention at each measuring point. Helium concentrations remained relatively constant throughout the test, while oxygen levels steadily dropped to below 1 percent after air injection ceased. Because the measured helium levels remained relatively constant, and since all oxygen loss was observed at all points, and because helium will diffuse approximately three times faster than oxygen, the measured oxygen loss can be attributed primarily to bacterial respiration rather than diffusion of faulty MP construction.

Calculations based on pilot test results indicate that, at site ST14, an estimated 959 to 9,886 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year. This value was calculated as described in the protocol document (Hinchee et al., 1992) This value is the average of the fuel consumption rates calculated for every point at which a respiration test was conducted. The air-filled porosities as calculated for each sampling point ranged from 0.06 to 0.11 liters of air per kilogram of soil. The point-specific fuel consumption rates were calculated using observed oxygen utilization rates, estimated air-filled porosities, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Oxygen loss was rapid and linear at every sampling point during approximately the initial 500 minutes of the *in situ* respiration test. The oxygen utilization rates observed at site ST14 ranged from 0.016 percent per minute (%/min) to 0.045 %/min (Table 5), demonstrating that hydrocarbon contamination is spread uniformly through the pilot test area.

At all sampling points, the oxygen utilization rates appeared to decrease over time (Figures 7 and 11). This apparent decrease has been observed at other fuel spill sites where an oxygen source is in close proximity to contaminated soils. Site ST14 is unpaved, and initial oxygen levels in the vent well, MPA-4, and MPC-7 ranged from 0.8 to 3.8 percent (Table 2), suggesting the potential for oxygen diffusion from the surface. As oxygen is rapidly consumed by fuel-degrading bacteria in deeper contaminated soils, the oxygen diffusion gradient between the contaminated soil and the atmosphere becomes substantial. As a result, oxygen begins to diffuse from the atmosphere into the contaminated soils. This inward oxygen diffusion temporarily masks the actual bacterial oxygen uptake rates. Because fuel biodegradation generally consume oxygen at a rate that exceeds diffusion, the oxygen concentrations soon return to zero in contaminated soils once supplied air is cut off.

Potential Air Emissions

Soil concentrations of BTEX compounds detected were less than 50 mg/kg; however, the free product present at Site ST14 will continue to generate additional VOCs (Table 1). Thus, the long-term potential for air emissions from full-scale bioventing operations at this site is moderate. Initial emissions should be minimal

because accumulated vapors will move slowly outward from the air injection point and will be biodegraded as they move horizontally through the soil. The low permeability clays near the surface provide a cover at the site which will also encourage horizontal movements and increased biodegradation. During the air permeability test, air was injected at 28 acfm. Hydrocarbon-analyzer air monitoring of the breathing zone at the site for health and safety purposes did not indicate that hydrocarbon concentrations had increased above 1 part per million volume (ppmv) during the test.

RECOMMENDATIONS

Initial bioventing tests at this site indicate that oxygen had been depleted in the contaminated soils, and that air injection is an effective method of stimulating aerobic fuel biodegradation. It is recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A 1-horsepower regenerative blower has been installed at the site for continuous air injection. In December 1993, additional tests at the site should be conducted to sample and analyze the soil gas and conduct a repeat respiration test. If a bioventing system for a full-scale remediation of the site has not been installed by June 1994, a final respiration test should be conducted, at which time soil and soil gas samples can be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment. It is important to note that without some form of free product removal, soils will be subject to recontamination as groundwater levels rise.

Based on the results of this 1-year study, AFCEE will recommend one of two options:

1. Upgrade the pilot-scale system, if necessary, and continue operation of the bioventing system for full-scale remediation of the site. Evaluate the need for integrating bioventing with free product recovery. AFCEE can assist the base in obtaining regulatory approval for upgrading and continued operation.
2. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the vent well and MPs.

REFERENCES

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing*. Prepared for USAF Center for Environmental Excellence. May.

Appendix A

O&M Instructions for Blower

BLOWER SYSTEM OPERATIONS AND MAINTENANCE MANUAL FOR EXTENDED PILOT TESTING SYSTEM

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
CARSWELL AFB, TEXAS

USAF CONTRACT F41624-92-D-8036, DELIVERY ORDER 14

August 1993

Prepared by:

Engineering-Science, Inc.
7800 Shoal Creek Blvd., Suite 222W
Austin, Texas 78757

320SA\AU380\EXT-PLT

CONTENTS

SECTION 1

INTRODUCTION

This document has been prepared by Engineering-Science, Inc. to support the bioventing initiative contract awarded by the Air Force Center for Environmental Excellence. The contract involves the conducting of bioventing pilot tests at 35 sites on 23 Air Force bases across the United States.

At most sites, bioventing systems will be installed upon completion of the initial bioventing pilot tests for the purpose of extended pilot testing. These systems will operate for a 1-year period to provide further information as to the feasibility of the technology at each site, and to provide interim remedial action.

This Operations and Maintenance Manual has been created for sites at which regenerative or rotary-vane blowers have been installed for extended pilot testing. Basic maintenance of these systems is the responsibility of the Air Force facility. This manual is to be used by facility personnel to guide and assist them in operating and maintaining the blower system. Section 2 provides a summary of the bioventing system components installed. Section 3 of this document describes the blower system. Section 4 details the maintenance requirements and provides maintenance schedules. Section 5 describes the system monitoring that is required to forecast system maintenance needs and to provide data for the extended pilot test. Blower performance curves and relevant service information for regenerative blowers are provided in Appendix A, and a data collection sheet is provided in Appendix B.

SECTION 2

BLOWER SYSTEM CONFIGURATION SUMMARY

System Type (injection, extraction): Injection

Blower (regenerative, rotary vane): Regenerative

Blower Model: GAST® R4110N-50

Motor (Hp): 1

Inlet Vacuum Gauge (range): 0 - 60" of H_2O

Inlet Filter (part no.): AJ 134E

Outlet Temperature Gauge (range): 0 - 250°F

Outlet Pressure Gauge (range): 0 - 100" of H_2O

Pressure Relief Valve Set @ (give unit of measure): 52" of H_2O

SECTION 3

BIOVENTING SYSTEM OPERATION

3.1 PRINCIPLE OF OPERATION

Bioventing is the forced injection of fresh air, or withdrawal of soil gas, to enhance the supply of oxygen for *in situ* bioremediation. Either a pressure (air injection) or vacuum (vapor extraction) blower unit is used to inject or withdraw air into or from the soil, thereby supplying fresh air with approximately 20.8 percent oxygen to the contaminated soils. Once oxygen is provided to the subsurface, existing bacteria will proceed with the breakdown of fuel residuals.

At Carswell Air Force Base ST14 site an injection blower system has been installed.

3.2 SYSTEM DESCRIPTION

3.2.1 Blower System

A regenerative blower (GAST® R1140N-50) powered by a 1-horsepower direct-drive motor is the workhorse of the bioventing system. This blower is rated at a flow rate of 92 standard cubic feet per minute (scfm) at a pressure of 51 inches of water ; however, the actual performance of the blower will vary with changing site conditions. As installed, the blower was producing an estimated flow rate of 15 actual cfm at a pressure of 48 inches of water. The system includes an air filter to remove any particulates which are entrained in the air stream, and several valves and monitoring gauges which are described in the next section. A schematic of the blower system installed at Carswell Air Force Base is shown on the as-built drawings. Corresponding blower performance curves, and relevant service information are provided in Appendix A.

3.2.2 Monitoring Gauges

The bioventing system is equipped with vacuum and pressure gauges, and temperature gauges. Gauges have been installed on the system at the following locations: a vacuum gauge in the inlet piping and a pressure gauge in the outlet piping. In addition, a temperature gauge is provided in the discharge piping. As-built drawing, sheet number 1 shows the locations of the gauges installed on the blower system at this site. Temperature gauges may be located at the inlet and outlet of the blower system. These gauges are used to monitor the inlet and outlet temperature to determine the change in temperature across the blower. For the

Carswell AFB system, ambient air temperature should be used as an inlet temperature gauge is not provided.

SECTION 4

SYSTEM MAINTENANCE

Although the motor and blower are relatively maintenance free, periodic system maintenance is required for proper operation and long life. Recommended maintenance procedures and schedules are described in detail in the instruction manuals included in Appendix A, and briefly summarized in this section.

Filter inspection must be performed with the system turned off. To re-start the motor, open the manual air pressure release valve to protect the motor from excessive strain, start motor, and slowly close the pressure release valve.

4.1 Blower/Motor

The blower and motor are relatively maintenance free and should not require any periodic maintenance during the 1-year extended testing period. Both blower and motor have sealed bearings and do not require lubrication.

4.2 AIR FILTER

To avoid damage caused by passing solids through the blower, an air filter has been installed in-line before the blower. The filter element is paper and is accompanied by a polyurethane foam prefilter. The filter should be checked weekly for the first 2 months of operation. Again, a facility employee should determine the best schedule for filter replacement. The polyurethane prefilters can be washed with lukewarm water and a mild detergent. Paper filter elements should never be washed, but should be disposed of and replaced as necessary. When the vacuum drop across the filter is above 15 inches of water, a dirty filter element should be suspected, and cleaning or replacement should be performed.

To remove the filter, loosen the three clamps or the wing nut, lift the metal top off the air filter, and lift the air filter from the metal housing. Remove the polyurethane prefilter (if applicable) and wash before replacing. When replacing the filter, be careful that the rubber seals remain in place.

The filter element is manufactured by Solberg Manufacturing, Inc. in Itasca, Illinois. Their telephone number is (708) 773-1363. Additional filters can also be obtained through Engineering-Science, Inc. in Denver, Colorado. The ES contacts are Mr. Brian Blicker and Mr. John Hall and they can be reached at (303) 831-8100. The filter model number is F-30P-150, and the number for the replacement element is 30P. It is recommended that the base keep at least one spare air filter at the site; four spare filters were supplied with the blower system.

4.3 MAINTENANCE SCHEDULE

The following maintenance schedule is recommended for this system. During the initial months of operation more frequent monitoring is recommended to ensure that any startup problems are quickly corrected. A daily drive-by inspection is recommended during the initial 2 weeks of operation to ensure that the blower system is still operating with no unusual sounds. Data collection sheet that can be used to record maintenance activities is included in Appendix B.

Maintenance Item	Maintenance Frequency
Filter	Check once per month, wash or replace as necessary (see Section 4.2).

4.4 MAJOR REPAIRS

Blowers systems are very reliable when properly maintained. Occasionally, a motor or blower will develop a serious problem. If a blower system fails to start, and a qualified electrician verifies that power is available at the blower or starter, the Engineering-Science, Inc. site manager Mr. Brian Vanderglas should be called at (512) 467-6200. ES is responsible for major repairs during the first year of operation.

SECTION 5

SYSTEM MONITORING

5.1 BLOWER PERFORMANCE MONITORING

To monitor the blower performance, vacuum, pressure, and temperature will be measured. These data should be recorded weekly on a data collection sheet (provided in Appendix B). All measurements should be taken at the same time while the system is running. Because the system is loud, hearing protection should be worn at all times.

5.1.1 Vacuum/Pressure

With hearing protection in place, open the blower enclosure and record all vacuum and pressure readings directly from the gauges (in inches of water). Record the measurements on a data collection sheet (Appendix B).

5.1.2 Flow Rate

The flow rate through the vent well and soils can be calculated when the inlet vacuum and outlet pressure of the blower are known. This pressure change across the blower (vacuum + pressure) can be compared to the performance curves for the blower in Appendix A to determine the approximate flow rate.

5.1.3 Temperature

With hearing protection in place, open the blower enclosure and record the temperature readings directly from the gauge in degrees Fahrenheit (°F). Record the measurement on a data collection sheet (provided in Appendix B). The temperature change can be converted to degrees Celsius (°C) using the formula °C= (°F - 32) X 5/9.

5.3 MONITORING SCHEDULE

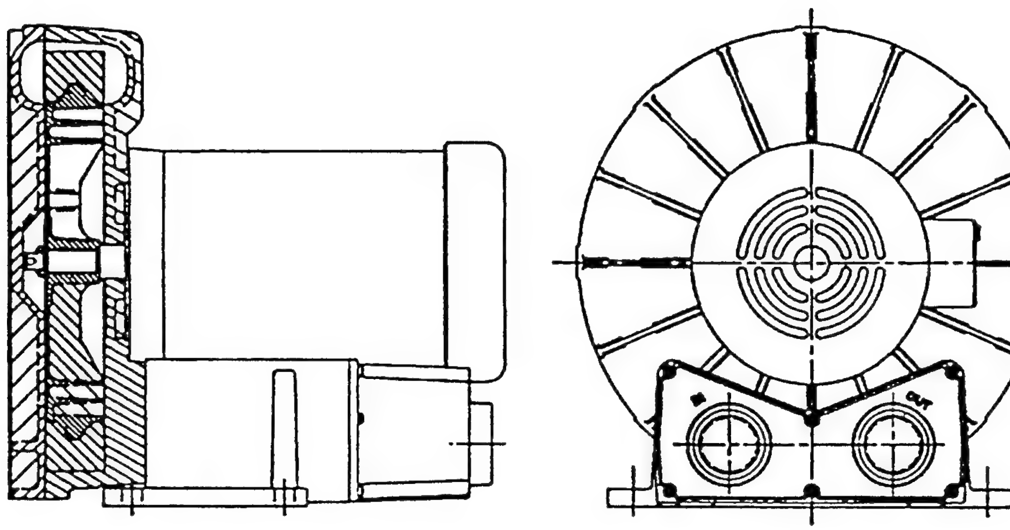
The following monitoring schedule is recommended for this system. During the initial months of operation, more frequent monitoring is recommended to ensure that any start up problems are quickly corrected. Data collection sheets have been provided to assist your data collection and are included in Appendix B.

Monitoring Item	Monitoring Frequency
Vacuum/Pressure	Daily during first week, then once per week.
Temperature	Daily during first week, then once per week.

APPENDIX A
REGENERATIVE BLOWER INFORMATION

Post Office Box 97
Benton Harbor, Michigan 49023-0097
Ph: 616/926-6171
Fax: 616/925-8288

Maintenance Instructions for Gast Standard Regenerative Blowers



For original equipment manufacturers special models, consult your local distributor

Gast Rebuilding Centers

Gast Mfg. Corp.
2550 Meadowbrook Rd.
Benton Harbor MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Gast Mfg Corp.
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Brenner Fiedler. & Assoc.
13824 Bentley Place
Cerritos, CA. 90701
Ph: 213/404-2721
Fax: 213/404-7975

Wainbee, Limited
121 City View Drive
Toronto, Ont. Canada M9W 5A9
Ph: 416/243-1900
Fax: 416/243-2336

Wainbee, Limited
215 Brunswick Drive
Pointe Claire, P.Q. Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/697-3070

Gast Mfg. Co. Limited.
Halifax Rd, Cressex Estate
High Wycombe, Bucks HP12 3SN
Ph. 44 494 523571
Fax: 44 494 436588

Japan Machinery Co. Ltd.
Central PO Box 1451
Tokyo 100-91 Japan
Ph: 813/3573-5421
Fax: 813/3571-7865

FOR SOIL VAPOR

designed to supply up to 420 cfm [714m 3/hr], 7 in Hg/224 mbar [90" H_2O] or 4 psi/249 mbar [100" H_2O]

The Gast reputation for quality and customer satisfaction is renowned throughout the world. Since 1921 we have been supplying air moving products that have set the industry standard of excellence. Our regenerative blowers for soil vapor extraction are no exception. Designed to extract vapors from contaminated soils, these models are used in conjunction with site-supplied special filters which clean the contaminants before venting them to the atmosphere. Since this process can take months or even years, Gast environmental blowers are a perfect solution; the only wearing part is the bearing, which is rated for up to 25,000 hours of service. Also, each of our motor-mounted models comes with a Class 1 Group D explosion-proof motor as a standard feature. Combining this quality with the strongest warranty in the business and a vast national and international distribution network providing product and technical support, we think you'll find our special Gast Regenair® blowers to be the right choice for your soil vapor extraction needs.

MODEL R4 SERIES
48" H_2O MAX. VAC., 51" H_2O MAX. PRESSURE
92 CFM OPEN FLOW

MODEL R5 SERIES
60" H_2O MAX. VAC., 65" H_2O MAX. PRESSURE
160 CFM OPEN FLOW

MODEL R6 SERIES
70" H_2O MAX. VAC., 75" H_2O MAX. PRESSURE
215 CFM OPEN FLOW

MODEL R6P SERIES
85" H_2O MAX. VAC., 100" H_2O MAX. PRESSURE
280 CFM OPEN FLOW

MODEL R7 SERIES
90" H_2O MAX. VAC., 90" H_2O MAX. PRESSURE
420 CFM OPEN FLOW

PRODUCT FEATURES
- Explosion-proof motors UL (class 1, group D)
- Sealed air stream
- Rugged construction
- Low maintenance

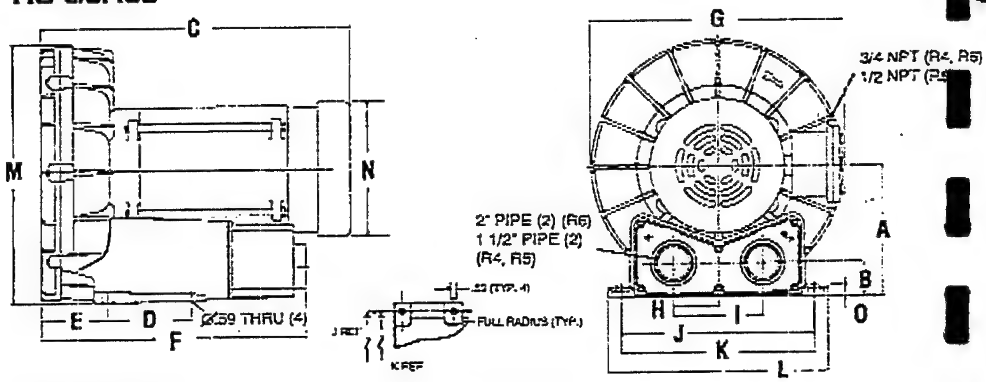
Product Dimensions

Metric [mm] / U.S. Imperial [inches]

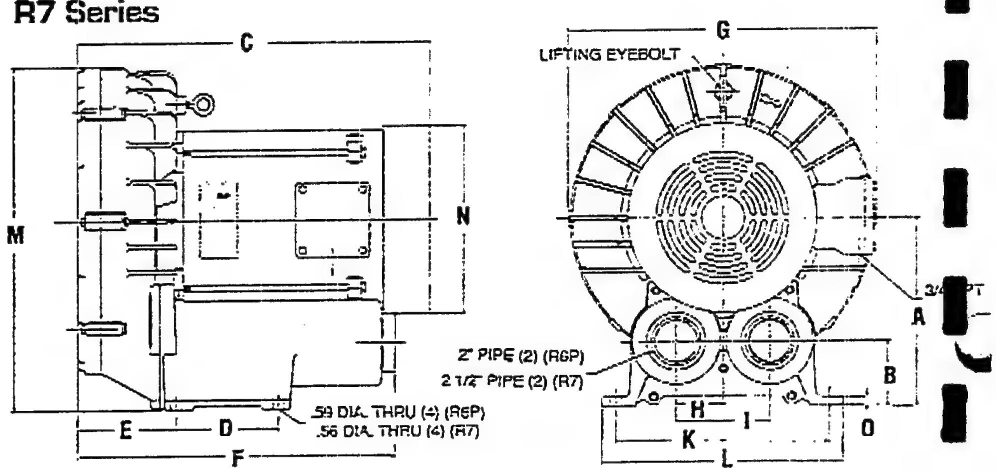
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
R4110N-50	157	43	389	95	72	316	313	50	101	225	227	254	293	175	[illegible]
	6.18	1.68	15.30	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	[illegible]
R4310P-50	157	43	356	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.03	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	[illegible]
R5125Q-50	178	46	445	114	91	361	344	60	121	260	262	298	350	173	[illegible]
	7.00	1.82	17.50	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	6.81	.59
R5325R-50	178	46	423	114	91	361	344	60	121	260	262	298	350	183	[illegible]
	7.00	1.82	16.66	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	7.19	[illegible]
R6130Q-50	197	49	511	140	98	404	389	62	125	289	290	329	391	217	13
	7.75	1.94	20.13	5.50	3.85	15.89	15.30	2.46	4.92	11.38	11.42	12.96	15.38	8.56	.52
R6P1550Q-50	248	80	602	140	137	438	428	64	127	–	290	325	463	257	[illegible]
	9.77	3.15	23.7	5.51	5.39	17.25	16.87	2.50	5.00	–	11.42	12.80	18.21	10.12	[illegible]
R6P355R-50	248	80	554	140	137	438	428	64	127	–	290	325	463	257	13
	9.77	3.15	21.80	5.51	5.39	17.25	16.87	2.50	5.00	–	11.42	12.80	18.21	10.12	[illegible]
R7100R-50	274	92	577	216	212	545	457	100	200	–	375	410	509	257	[illegible]
	10.79	3.64	22.72	8.50	8.33	21.46	18.00	3.94	7.88	–	14.76	16.14	20.02	10.12	.56

Notice: Specifications subject to change without notice.

R4 Series
R5 Series
R6 Series



R6P Series
R7 Series



More models may be available – please consult factory

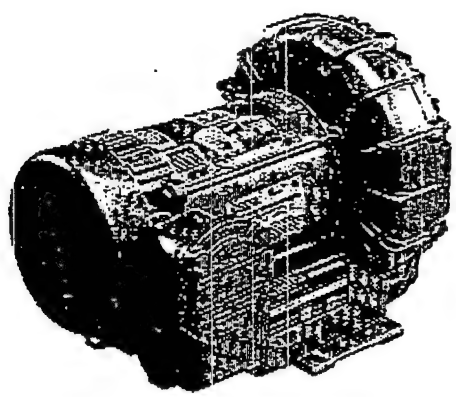
EXTRACTION...

Product Specifications

Model Number	Hz	Motor Specs	Full Load Amps	HP	RPM	Max Vac "H_2O	Max Vac mbar	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m^3h	Net Wt. lbs.	Net Wt. kg
R4110N-50	50	110/220-240-50-1*	9.2/5.2-4.6	0.6	2850	35	87	38	95	74	126	60	2
	60	115/208-230-60-1*	11.4/6.2-5.6	1.0	3450	48	120	51	127	92	156		
R4310P-50	50	220/380-50-3*	3.2/1.6	0.6	2850	35	87	38	95	74	126	58	2
	60	208-230/460-60-3*	3.4-3.3/1.65	1.0	3450	48	120	51	127	92	156		
R5125Q-50	60	115/230-60-1	25/12.5	2.0	3450	60	149	55	137	160	272	77	3
R5325R-50	50	190-220/380-415-50-3	5.0-4.4/2.5-2.6	1.5	2850	47	117	50	125	133	226	75	3
	60	208-230/460-60-3	6.0-5.6/2.8	2.0	3450	60	149	65	162	160	272		
R6130Q-50	50	220-240-50-1	14.7-13.5	2.5	2850	65	162	75	187	182	309	129	5
	60	230-60-1	16.3	3.0	3450	70	174	60	149	215	365		
R6P155Q-50	50	220-240-50-1	20.8-19.1	4.0	2850	65	162	80	199	235	399	243	11
	60	230-60-1	29.9	5.5	3450	85	212	95	237	280	476		
R6P355R-50	50	190-220/380-415-50-3	14.9-11/7.45-5.8	4.5	2850	65	162	80	199	232	394	233	10
	60	208-230/460-60-3	20-18/9	6.0	3450	85	212	100	249	280	476		
R7100R-50	50	190-220/380-415-50-3	20.8-18.9/10.4-9.5	8	2850	72	179	80	199	350	595	297	13
	60	208-230/460-60-3	26.5-24/12	10	3450	90	224	90	224	420	714		

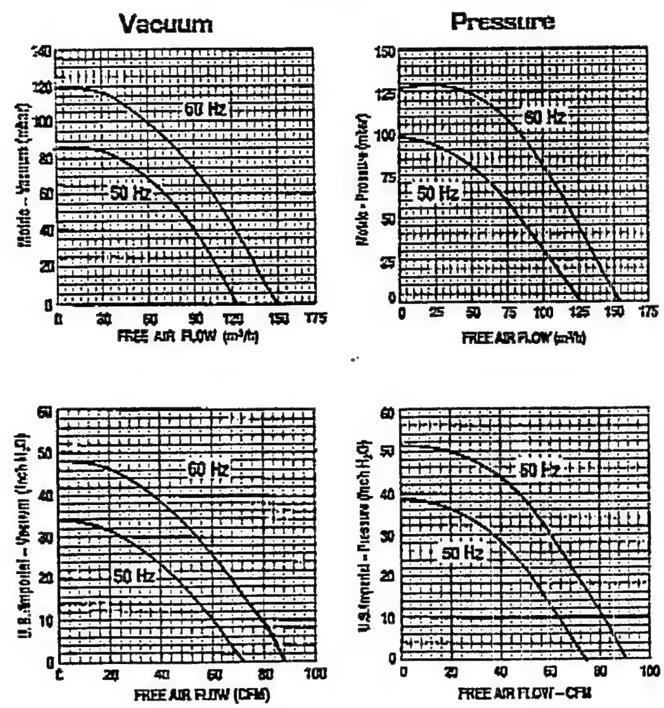
*Models have automatic reset thermal protection.

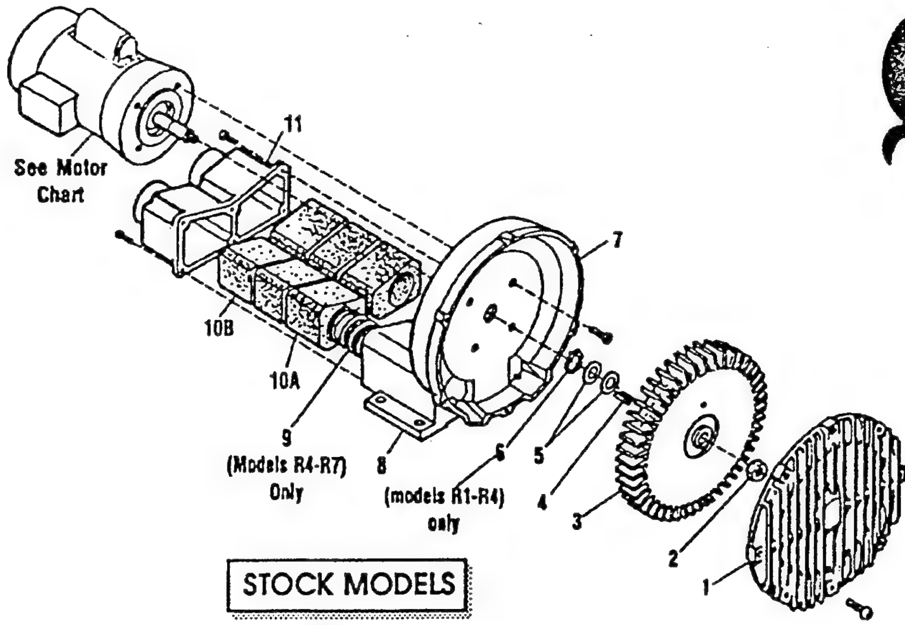
Product Performance
(Metric/U.S. Imperial)



NOTE: These units with explosion-proof motors are designed specifically for qualified OEMs in the soil vapor extraction industry. They are not intended to be applied for other uses without written acknowledgment from an authorized employee of Gast Manufacturing Corporation.

Model R4 Series





STOCK MODELS

Part Name	R1	R2	R3	R4	R5	R6	R6P	R6PP/R6PS	R7
#1 Cover	AJ101A	AJ101B	AJ101C	AJ101D	AJ101EQ	AJ101F	AJ101K	(2)AJ101KA	AJ101G
#2 Stopnut	BC187	BC187	BC181	BC181	BC181	BC181	BC181	(2)BC182	BC183
#3 Impeller	AJ102A	AJ102BQ	AJ102C	AJ102D	AJ102E	AJ102FR	AJ102K	(2)AJ102KA	AJ102GA
#4 Square Key	AH212C	AH212	AB136A	AB136D	AB136	AB136	AB136	(2)AB136	AC628
#5 Shim Spacer (s)	AJ132	AE686-3	AJ109	AJ109	AJ109	AJ116A	AJ116A	AJ116A	AJ110
#6 Retaining Ring	AJ145	AJ145	AJ149	AJ149					
#7 Housing	AJ103A	AJ103BQ	AJ103C	AJ103DR	AJ103E	AJ103F	AJ103K	AJ103KD	AJ103GA
#8 Muffler Box					AJ104E	AJ104F			
#9 Spring				AJ113DR	AJ113DQ	AJ113FQ	AJ113FQ		AJ113G
#10A Foam	(4)AJ112A	(4)AJ112B	(4)AJ112C	(4)AJ112DS	(4)AJ112ER	(6)AJ112F	(8)AJ112K		(8)AJ112GA
#10B Foam		(2)AJ112BQ	(2)AJ112CQ	(2)AJ112DR	(2)AJ112EQ				
#11 Muffler Extension/ Adapter Plate	AJ106H	AJ106BQ	AJ106CQ	AJ106DQ	AJ106EQ	AJ106FQ	AJ104K		AJ104GA
Shim Kit	K396	K396							K395

MOTOR CHART

REGENAIR MODEL NUMBER	MOTOR NUMBER	MOTOR SPECIFICATIONS 60 HZ VOLTS	50 HZ VOLTS	PHASE
R1102	J111X	115/208-230	110/220-240	1
R1102C	J112X	115		1
R2103	J311X	115/208-230	110/220	1
R2105	J411X	115/208-230	110/220	1
R2303A	J310	208-230/460	220/380-415	3
R2303F	J313	208-230	220	3
R3105-1/R3105-12	J411X	115/208-230	110/220-240	1
R3305A-1/R3305A-13	J410	208-230/460	220/380-415	3
R4110-2	J611AX	115/208-230	110/220-240	1
R4310A-2	J610	208-230/460	220/380-415	3
R5125-2	J811X	115/208-230		1
R5325A-2	J810X	208-230/460	220/380-415	3
R6125-2	J811X	115/208-230		1
R6325A-2	J810X	208-230/460	220/380-415	3
R6335A-2	J910X	208-230/460	220/380-415	3
R6150J-2	J1013	230		1
R6350A-2	J1010	208-230/460	220/380-415	3
R6P335A	J910X	208-230/460	220/380-415	3
R6P350A	J1010	208-230/460	220/380-415	3
R6P355A	J1110A	208-230/460	220/380-415	3
R7100A-2*	J1210B	208-230/460	220/380-415	3
R6PP/R6PS3110M	JD1100	208-230/460	220/380-415	3

* No lubrication needed at start up. Bearings lubricated at factory.

* Motor is equipped with alemite fitting. Clean tip of fitting and apply grease gun. Use 1 to 2 strokes of high quality ball bearing grease.

Consistency	*Type*	*Typical Grease*
Medium	Lithium	Shell Dolium R

Hours of service per year	*Suggested Relube Interval*
5,000	3 years
Continual NormalApplication	1 year
Seasonal service motor idle for 6 months or more	1 year beginning of season
Continuous-high ambients, dirty or moist applications.	6 months

60 HZ FLOW DATA (CFM)

All performance figures relate to stock models. A few high pressure units may be available. Consult your local distributor.

Regenair Model Number	PRESSURE 0"H_2O	20"H_2O	40"H_2O	60"H_2O	80"H_2O	100"H_2O	Maximum Pressure "H_2O*
R1	26	14					28
R2	42	26					38
R3105-1	52	38	14				42
R3105-12	52	36	23				55
R3305A-13	52	36	23				55
R4	90	70	50				52
R5	145	130	100				65
R6125-2	200	180					35
R6325A-2	200	180	152				40
R6335A-2	205	175	155	135			70
R6350A-2	200	180	150	130	110	80	105
R6P335A	290	250					30
R6P350A	300	260	230	200			60
R6P355A	300	260	230	200	160		90
R7100A-2	420	380	340	310	280	230	115
R6PP311OM	485	452	420	380	330		95
R6PS311OM	265	258	252	244	236	226	170

Regenair Model Number	VACUUM 0"H_2O	20"H_2O	40"H_2O	60"H_2O	80"H_2O	Maximum Vacuum "H_2O*
R1	25	14				26
R2	40	22				34
R3105-1	50	34	9			40
R3105-12	51	34	20			50
R3305A-13	51	34	20			50
R4	82	62	39			48
R5	140	115	90	50		60
R6125-2	190	155	125			45
R6325A-2	190	155	125			45
R6335A-2	190	150	125	100		75
R6350A-2	190	180	150	100	70	90
R6P335A	270	230				37
R6P350A	280	240	210	170		70
R6P355A	280	240	210	170	100	86
R7100A-2	410	350	300	250	170	90
R6PP311OM	470	425	375	320	220	80
R6PS311OM	240	225	210	195	175	130

***This number indicates the maximum static pressure differential recommended (with cooling air still flowing through unit). In general, units 1hp or less can be dead headed. Check with local representative or distributor to verify which models apply.**

Operation of the blower above the recommended maximum duty will cause premature failure due to the build up of heat damaging the components.

Performance data was determined under the following conditions:

1) Unit in a temperature stable condition.
2) Test conditions: Inlet air density at 0.075lbs. per cubic foot. (20°C(68°F), 29.92 in. Hg(14.7PSIA)).
3) Normal performance variations on the resistance curve within +/- 10% of supplied data can be expected.
4) Specifications subject to change without notice.
5) All performance at 60Hz operation.

70-6100
F2-205/8/92
AK811 Rev. E

GAST®

Post Office Box 97
Benton Harbor, MI. 49023-0097
Ph: 616/926-6171
Fax: 616/925-8288

INSTALLATION AND OPERATING INSTRUCTIONS FOR GAST HAZARDOUS DUTY REGENAIR BLOWERS

This instruction applies to the following models ONLY: R3105N-50, R4110N-50, R4310P-50, R4P115N-50, R5125Q-50, R5325R-50, R6130Q-50, R6P155Q-50, R6350R-50, R6P355R-50 and R7100R-50.

Gast Authorized Service Facilities are Located in the locations listed below

Gast Manufacturing Corporation
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Gast Manufacturing Corporation
2550 Meadowbrook Road
Benton Harbor, MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Brenner Fiedler & Associates
13824 Bentley Place
Cerritos, CA. 90701
Ph: 213/404-2721
Ph: 800/843-5558
Fax: 213/404-7975

Wainbee Limited
215 Brunswick Blvd.
Pointe Claire, Quebec
Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/-697-3070

Wainbee Limited
5789 Coopers Ave.
Mississauga, Ontario
Canada L4Z 3S6
Ph: 416/243-1900
Fax: 416/243-2336

Japan Machinery
Central PO Box 1451
Toyko 100-91, Japan
Ph: 813 3573-5421
Fax: 813 3571-7896

Gast Manufacturing Co. Ltd.
Halifax Road, Cressex Estate
High Wycombe, Bucks HP12 3S
England
Ph: 44 494 523571
Fax: 44 494 436588

Safety

⚠ This is the safety alert symbol. When you see this symbol, personal injury is possible. The degree of injury is shown by the following signal words:

⚠ DANGER: Severe injury or death will occur if hazard is ignored.

⚠ WARNING: Severe injury or death can occur if hazard is ignored.

⚠ CAUTION: Minor injury or property damage can occur of hazard is ignored.

Review the following information carefully before operating.

General Information

⚠ DANGER: Do not pump flammable or explosive gases or operate in an atmosphere containing them. Ambient temperature for normal operation should not exceed 40 degrees C (105 degrees F). For higher ambient operation, consult the factory. Blower performance is reduced by the lower atmospheric pressure of high altitudes. If it applies to this unit, consult a Gast distributor or the factory for details.

Installation

⚠ WARNING: Electric Shock can result from bad wiring. Wiring must conform to all required safety codes and be installed by a qualified person.

Grounding is required.

The Gast Regenair blower can be installed in any position. The flow of cooling air over the blower and motor must not be blocked.

PLUMBING - The threaded pipe ports are designed as connection ports only and will not support the plumbing. Be sure to use the same or larger size pipe and fittings to prevent air flow restriction and over-heating of the blower. When installing plumbing, be sure to use a small amount of pipe thread lubricant. This protects the threads in the aluminum blower housing. Dirt and chips, often found in new plumbing, should not be allowed to enter the blower.

NOISE - To reduce noise and vibration, the unit should be mounted on a solid surface that will not increase sound. The use of shock mounts or vibration isolation material is recommended. If needed, inlet or discharge noise can be reduced by attaching muffler assemblies (see accessories).

ROTATION - The Gast Regenair blower should only rotate clockwise as viewed from the electric motor side. This is marked with an arrow in the casting. Proper rotation can be confirmed by checking air flow at the IN and OUT ports. On blowers powered by a three phase motor, rotation is reversed by changing any two of the three power wires.

Operation

⚠ WARNING: Solid or liquid material exiting the blower or piping can cause eye damage or skin cuts. Keep away from air stream.

⚠ CAUTION: Attach blower to solid surface before starting. Prevent injury or damage from unit movement.

Air containing solid particles or liquid must pass through a filter before entering the blower (see accessories list for filter suggestions). Blowers must have mufflers, filters, other accessories and all piping attached before starting. Any foreign material passing through the blower may cause internal damage.

⚠ CAUTION: Outlet piping can burn skin. Guard or limit access.

Mark "CAUTION Hot surface. Can cause burns."

Air temperature increases when passing through the blower. When run at duties above 50 in. H_2O, metal pipe may be required for hot exhaust air.

The blower must not be operated above the limits for continuous duty. 'Standard' R1, R2, R3 and R4 can operate continuously with not air flowing through the blower. Other units can only be run at the rating shown on the model number label. Do *not* close off inlet (for vacuum) or exhaust (for pressure) to reduce extra air flow. This could cause added heat and motor load.

ACCESSORIES - Gast pressure gauges AJ496 or AE133 and vacuum gauges AJ497 or AE134 show blower duty. The Gast pressure/vacuum relief valve, AG258, will limit the operating duty by admitting or relieving air. It also allows full flow through the blower when the relief valve closes.

Servicing

⚠ WARNING: Disconnect electric power before servicing. Be sure rotating parts have stopped. Electric shock or severe cuts can result. Inlet and exhaust filters need occasional cleaning or replacement of the elements. Failure to do so will result in more pressure drop, reduced air flow and hotter operation. The outside of the unit requires cleaning of dust and dirt. The inside of the blower also may need cleaning to remove material coating the impeller and housing. If not done, the buildup can cause vibration, hotter operation and reduced flow. Noise absorbing foam in the mufflers may need replacement.

KEEP THIS INFORMATION WITH THE BLOWER. REFER TO IT FOR SAFE INSTALLATION, OPERATION OR SERVICE.

TROUBLESHOOTING

Symptom	*Possible Diagnosis*	*Possible Remedy*
Excess Vibration	Impeller damaged by foreign material Impeller contaminated by foreign material	Replace impeller Clean impeller, install adequate filtration.
Abnormal sound	Motor bearing failed Impeller rubbing against cover or housing	Replace bearings Repair Blower, check clearances.
Increase in sound	Foreign material can coat or destroy muffler foam.	Replace foam muffler elements, trap or filter foreign material.
Blown fuse	Electrical wiring problem	Have qualified person check fuse capacity and wiring.
Unit very hot	Running at too high a pressure or vacuum	Install a relief valve

OPERATING AND MAINTENANCE INSTRUCTIONS

SAFETY

This is the safety alert symbol. When you see this symbol personal injury is possible. The degree of injury is shown by the following signal words:

⚠ DANGER Severe injury or death will occur if hazard is ignored.

⚠ WARNING Severe injury or death can occur if hazard is ignored.

⚠ CAUTION Minor injury or property damage can occur if hazard is ignored.

Review the following information carefully before operating.

GENERAL INFORMATION

This instruction applies to the following models ONLY: R3105N-50, R4110N-50, R4310P-50, R4P115N-50, R5125Q-50, R5325R-50, R6130Q-50, R6P155Q-50, R6350R-50, R6P355R-50 and R7100R-50. These blowers are intended for use in Soil Vapor Extraction Systems. The blowers are sealed at the factory for very low leakage. They are powered with a U.L. listed electric motor Class 1 Div. 1 Group D motors for Hazardous Duty locations. Ambient temperature for normal full load operation should not exceed 40° C (105° F). For higher ambient operation, contact the factory.

Gast Manufacturing Corporation may offer general application guidance: however, suitability of the particular blower and/or accessories is ultimately the responsibility of the user, not the manufacturer of the blower.

INSTALLATION

⚠ *DANGER Models R5325R-50, R6130Q-50, R6350R-50, R5125Q-50, R6P155Q-50, R6P355R-50 AND R7100R-50 use Pilot Duty Thermal Overload Protection. Connecting this protection to the proper control circuitry is mandated by UL674 and NEC501. Failure to do so could/may result in a EXPLOSION. See pages 3 and 4 for recommended wiring schematic for these models.*

⚠ *WARNING Electric shock can result from bad wiring. A qualified person must install all wiring, conforming to all required safety codes. Grounding is necessary.*

⚠ *WARNING This blower is intended for use on soil vapor extraction equipment. Any other use must be approved in writing by Gast Manufacturing. Corp.* Install this blower in any mounting position. Do not block the flow of cooling air over the blower and motor.

PLUMBING - Use the threaded pipe ports for connection only. They will not support the plumbing. Be sure to use the same or larger size pipe to prevent air flow restriction and overheating of the blower. When installing fittings, be sure to use pipe thread sealant. This protects the threads in the blower housing and prevents leakage. Dirt and chips are often found in new plumbing. Do not allow them to enter the blower.

NOISE - Mount the unit on a solid surface that will not increase the sound. This will reduce noise and vibration. We suggest the use of shock mounts or vibration isolation material for mounting.

ROTATION - The Gast Regenair Blower should only rotate clockwise as viewed from the electric motor side. The casting has an arrow showing the correct direction. Confirm the proper rotation by checking air flow at the IN and OUT ports. If needed reverse rotation of three phase motors by changing the position of any two of the power line wires.

OPERATION

⚠ *WARNING Solid or liquid material exiting the blower or piping can cause eye damage or skin cuts. Keep away from air stream.*

⚠ *WARNING - Gast Manufacturing Corporation will not knowingly specify, design or build any blower for installation in a hazardous, combustible or explosive location without a motor conforming to the proper NEMA or U.L. standards.* Blowers with standard TEFC motors should never be utilized for soil vapor extraction applications or where local state and/or Federal codes specify the use of explosion-proof motors (as defined by the National Electric Code, Articles 100,500 c1990).

⚠ *CAUTION Attach blower to solid surface before starting to prevent injury or damage from unit movement.* Air containing solid particles or liquid must pass through a filter before entering the blower. Blowers must have filters, other accessories and all piping attached before starting. Any foreign material passing through the blower may cause internal damage to the blower.

⚠ *CAUTION Outlet piping can burn skin. Guard or limit access.* Mark *"CAUTION Hot Surface. Can Cause Burns".* Air temperature increases when passing through the blower. When run at duties above 50 in. H_2O, metal pipe may be required for hot exhaust air. The blower must not be operated above the limits for continuous duty. Only models R3105N-50, R4110N-50 and R4310P-50 can be operated continuously with no air flowing through the blower. Other units can only be run at the rating shown on the model number label. Do not Close off inlet (for vacuum) to reduce extra air flow. This will cause added heat and motor load. Blower exhaust air in excess of 230°F indicates operation in excess of rating which can cause the blower to fail.

ACCESSORIES ...Gast pressure gauge AJ496 and vacuum gauges AJ497 or AE134 show blower duty. The Gast pressure/vacuum relief valve, AG258, will limit the operating duty by admitting or relieving air. It also allows full flow through the blower when the relief valve closes.

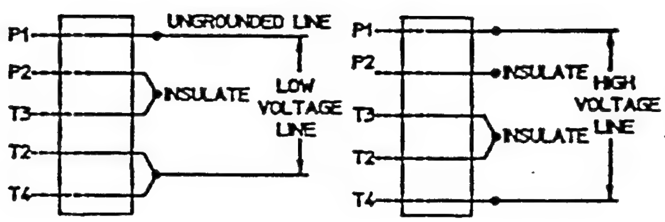
SERVICING

⚠ *WARNING To retain their sealed construction they should be serviced by Gast authorized service centers ONLY.* These models are sealed at the factory for very low leakage.

⚠ *WARNING Turn off electric power before removing blower from service. Be sure rotating parts have stopped. Electric shock or severe cuts can result.* Inlet and exhaust filters attached to the blower may need cleaning or replacement of the elements. Failure to do so will result in more pressure drop, reduced air flow and hotter operation of the blower. The outside of the unit requires cleaning of dust and dirt. The inside of the blower also may need cleaning to remove foreign material coating the impeller and housing. This should be done at a Gast Authorized Service Center. This buildup can cause vibration, failure of the motor to operate or reduced flow.

KEEP THIS INFORMATION WITH THIS BLOWER. REFER TO IT FOR SAFE INSTALLATION, OPERATION OR SERVICE.

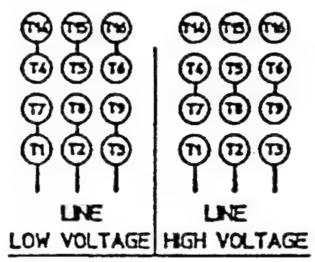
MOTOR WIRING DIAGRAM FOR R4110N-50 & R3105N-50



>>* WARNING
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

MOTORS WIRING DIAGRAM FOR R4310P-50

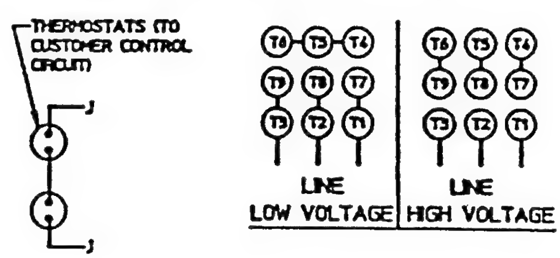
TO REVERSE ROTATION, INTERCHANGE THE EXTERNAL CONNECTIONS TO ANY TWO LEADS.



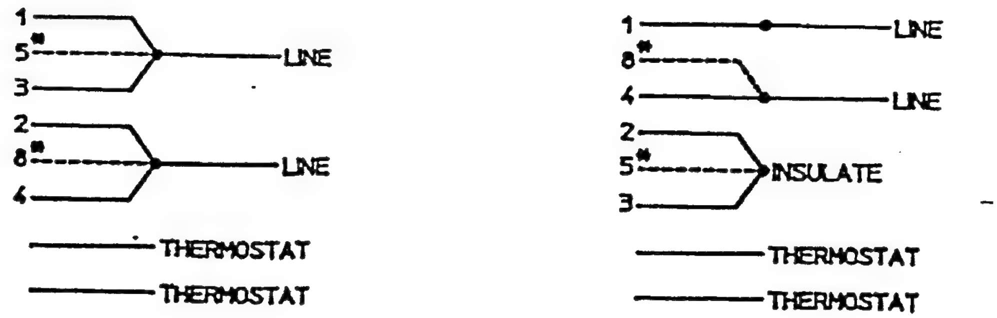
>>* WARNING
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

MOTORS WIRING DIAGRAM FOR R5325R-50, R6350R-50, R6P355R-50, & R7100R-50

TO REVERSE ROTATION, INTERCHANGE THE EXTERNAL CONNECTIONS TO ANY TWO LEADS.



MOTOR WIRING DIAGRAM FOR R5125Q-50 & R4P115N-50



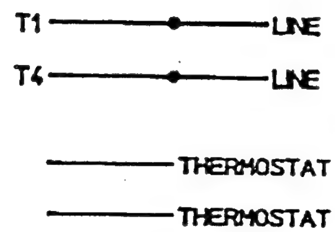
LOW VOLTAGE

HIGH VOLTAGE

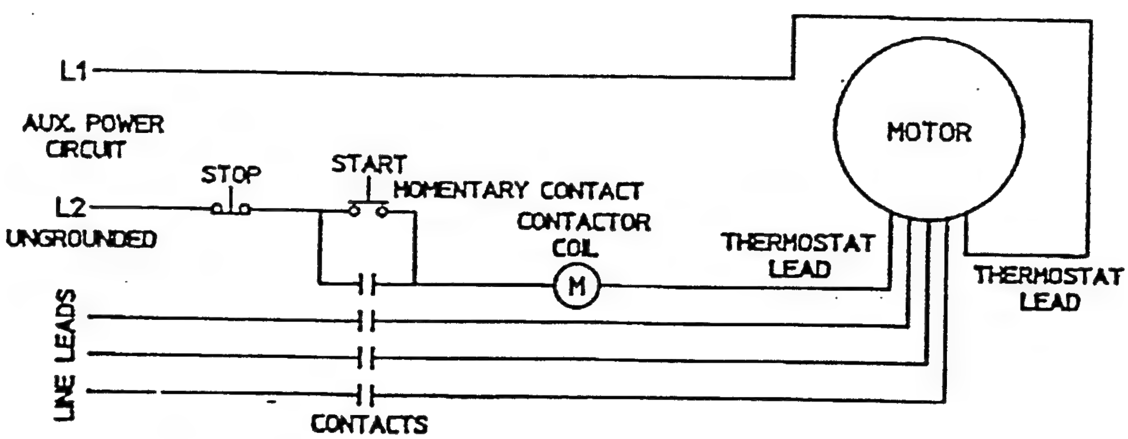
* R5125Q-50 BLOWERS PRODUCED AFTER SEPTEMBER 1992 (SER. NO. 0992) DO NOT HAVE MOTOR LEADS 5 & 8.

MOTOR WIRING DIAGRAM FOR R6130Q-50 & R6P155Q-50

CONNECT THERMOSTAT TO MOTOR PROTECTION CIRCUIT



CONNECTION FOR THERMOSTAT MOTOR PROTECTION

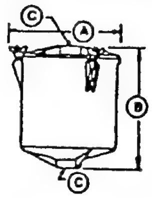


TERMOSTATS TO BE CONNECTED IN SERIES WITH CONTROL AS SHOWN. MOTOR FURNISHED WITH AUTOMATIC THERMOSTATS RATED A.C. 115-600V. 720VA

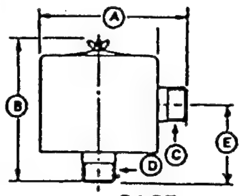
AK811 rev. E

REGENAIR ACCESSORIES

Inline Filters (for vacuum)



R1-R3

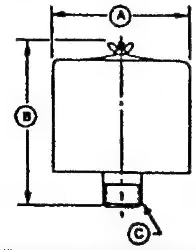


R4-R7

Model Number	R1 & R2	R3	R4, R5 &SDR4	R6P SDR5, SDR6 R6PP, R6PS	R7
Part #	AV460	AV460C	AG337	AJ151G	AJ151H
Dim A	8.25"	8.25"	11.75"	8.00"	16.25"
Dim B	8.875"	8.875"	4.75"	10.25"	27.13"
Dim C	1" FPT	1 1/4"FPT	1 1/2"MPT	2 1/2" MPT	3" MPT
Dim D	-	-	1 1/2" FPT	2 1/2"MPT	3" MPT
Dim E	-	-	2.38	5.50	18.50
Replacement Element	AV469	AV469	AG340	AJ135G	AJ135C
Micron	10	10	25	10	10

MPT = Male Pipe Thread
FPT = Female Pipe Thread

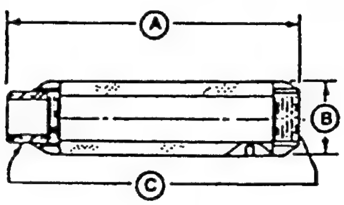
Inlet Filters (for pressure units only)



Model Number	R1 & R2	R3	R4, R5 &SDR4	R6, SDR5 SDR6, R6P R6PP, R6PS	R7
Part #	AJ126B	AJ126C	AG338	AJ126F	AJ126G
Dim A	6.00"	6.00"	10.63"	10.63"	10.00"
Dim B	4.62"*	7.12"*	4.81"*	4.81"*	13.12"*
Dim C	1" MPT	1 1/4" MPT	1 1/2" FPT	2" FPT	2 1/2" MPT
Replacement Element	AJ134B	AJ134C	AG340	AG340	AJ135A
Micron	10	10	25	25	10

All are heavy duty for high amounts of particulates. Inlet filters for REGENAIR blowers are drip-proof when mounted as shown.

Mufflers



Model Number	R2	R3	R4, R5 SDR 4* &SDR5*	R6, SDR6* R6P R6PP, R6PS	R7
Part #	AJ121B	AJ121C	AJ121D	AJ121F	AJ121G
Dim. A	7.46"**	7.94"**	12.75"**	17.05"**	17.44"**
Dim. B	2.38"	2.62"	3.25"	3.63"	4.25"
Dim. C	1" NPT	1 1/4" NPT	1 1/2" NPT	2" NPT	2 1/2" NPT

* For Inlet Only
** Approximately

Pressure-Vacuum Gauge

Pressure Gauge, Part #AJ496, 2 5/8" Diameter, 1/4" NPT, 0-60 inches H_2O and 0-150 mbar

Pressure Gauge, Part #AE133A, 2 5/8" Diameter, 1/4" NPT, 0-200 inches H_2O and 0-500 mbar

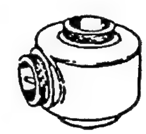
Vacuum Gauge, Part # #AJ497, 2 5/8" Diameter, 1/4" NPT, 0-60 inches H_2O and 0-150 mbar

Vacuum Gauge, Part #AE134, 2 5/8", Diameter, 1/4" NPT, 0-160 inches H_20 and 0-400 mbar

Fittings

Pipe Size	1"	1 1/4"	1 1/2"	2"	2 1/2"
Tee	BA415	BA431	BA432	BA433	BA434
Common Elbow	BA220	BA244	BA230	BA247	BA248
Nipple	BA752	BA809	BA783	BA810	BA813
Plastic Male Pipe Hose Barb	AJ117A	AJ117B	-	-	-
Hose I.D.	1.25	1.25	-	-	-
Metal Male Pipe Hose Barb	AJ117D	AJ117F	AJ117C	AJ117G	AJ117H
Hose I.D.	1.00	1.25	1.50	2.50	3.00

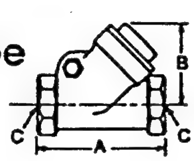
Relief Valve



Pressure/Vacuum Relief Valve, Part #AG258, 1 1/2" NPT, Adjustable 30-170 inches H_2O. 200 CFM maximum

Silencer for Relief Valve, Part #AJ121D

Horizontal Swing Type Check Valve



Model Number	R1, R2	R3	R4, R5 SDR 4 &SDR5	R6, SDR6 R6P R6PP, R6PS	R7
Part #	AH326B	AH326C	AH326D	AH326F	AH326G
Dim. A	3.57	4.19	4.50	5.25	8
Dim. B	2.32	2.69	2.94	3.82	5.07
Dim. C	1" NPT	1 1/4" NPT	1 1/2" NPT	2" NPT	2 1/2" NPT

APPENDIX B
DATA COLLECTION SHEET

Blower Injection System Data Collection Sheet
ST14 Site, Carswell AFB

Date	Time	Inlet Vacuum* (In. Water)	Inlet Temp.** (°F)	Outlet Pressure*** (In. water)	Outlet Temp.*** (°F)	Air Filter Changed (Y or N)	Blower Functioning (Y or N)	Comments	Checked By

* Gauge is located between the air filter and the blower.
** Same as ambient temperature.
*** Gauge is located on the outlet piping between the blower and the vent well.

Appendix B

Geologic Boring Logs

SHEET OF PAGE

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER VW1SB
PROJECT Bioventing
LOCATION POL Fuel Loading
DRILLING FIRM Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 5/25/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 5/25/93
GROUNDWATER LEVEL FIRST ENCOUNTERED ______ AND FINAL ______
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AMD CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	0-3½ split barrel sample	Fill No recovery. Clay, dark brownish black some odors, damp, some small gravel.	split spoon, no recovery
	0-3½'	Full recovery	Fill / gravel No recovery	split spoon 4000 ppm down hole. Headspace @ 3' = >5000 ppm
5	3½-8½	Full recovery	Olive gray, clay, some fine sand damp, few small gravel.	sample collected at 5-6' for BTEX & TPH
		sandy clay		Headspace @ 8½' = 5000 ppm
10	8½-11½	3' recovery 8½-11½	light gray Olive (mottled) damp clay, some nodules. No headspace sample collected due to high odors	sample collected at 10-11' for All analysis nutrients.
	11½-16½	3' recovery	@ 11' sandy clay (medium sand) moist. Light olive gray 11½' light olive gray medium to coarse sand with small gravel. saturated.	gravel 15½-16'
15				
20				
25				

SHEET OF PAGE

DRILL LOG

CLIENT ______ WELL OR BORING NUMBER MPA

PROJECT Bioventing LOCATION POL Tank Farm, Fuel loading

DRILLING FIRM Profile G.L. ELEVATION ______ LOGGER BRV

DRILLING RIG CME 75 HSA RIG OPERATOR Tom Placek.

BEGINNING 5/25/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 5/25/93

GROUNDWATER LEVEL FIRST ENCOUNTERED ______ AND FINAL ______

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	100% recovery	Olive black clay, light odors Few clay films. dry to damp	OVA scan = <50 ppm
	2-4'	100% recovery	olive gray clay, light odors some small nodules.	scan 50-200 ppm
5	3½-8½'	100% recovery	Black highly plastic clay large gravel (Fill) from 3½-5' damp.	OVA scan 50-250 ppm
			Light olive gray, dry to damp clay few small nodules. slight mottling	5000 ppm scan at 9½'
10	8½-13½'		light gray Fine sandy clay, moist odors	~~500-1000~~ ppm 500-1000
			light olive gray to olive at 13½'. ~~clay~~ sandy clay and clay intermixed damp	4000 @ 13'
			clayey sand, light olivegray at 13'.	
15			TD 13.5'	
20				
25				

SHEET OF PAGE

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER MPB
PROJECT Biovent Test System
LOCATION POL Tank Farm, Fuel loading area
DRILLING FIRM Profile Field services
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED 11.5' AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	No	Fill material, highly plastic black clay with large gravel Fill.	No recovery pushed shelby tube 1-3'.
5	3½-8½'		olive black, highly plastic clay w/ med to large gravel (fill), damp (oily)	odors,
			olive gray ~~sa~~ clay with little fine sand, few nodules (small) damp, plastic.	increasing odors Headspace @ 7' = >5000 ppm
10	8½-11½'		light olive gray to olive sandy clay (fine sand) moist to wet at 11½'. plastic soils	Headspace @ 10' = >5000 ppm
			TD ~~11.5'~~ BRV 11.2' TD tagged	
15				
20				
25				

SHEET OF

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER MPC
PROJECT Bioventing system
LOCATION Fuel loading area, POL
DRILLING FIRM Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	2' recovery	Brownish black clay with few small to medium gravel. damp	odors OVA Scan = 500 ppm
	2-4'	1½' recovery	olive gray silty clay, few small nodules, dry to damp. ~~weak~~ moderate structure	odors OVA Scan = 2000 ppm
5	3½-8½	4.2' recovery	olive black & ~~dark~~ olive gray clay very firm & plastic, damp. heavy odors. medium to large gravel from 3½ - 5'.	OVA scan = 2000 ppm
	8½ - ~~11½~~ 12'		light olive gray silty clay, many small nodules	~~OVA~~ OVA
10		4' recovery	light olive gray fine sandy clay, somewhat mottled, plasticity is high strong odors, ~~moist~~ damp to moist.	OVA = 3000 ppm
			light olive gray clayey fine sand, moist	heavy odors

TD = ~~11.5~~ 12.2'

15

20

25

SHEET OF

DRILL LOG (SB1)

CLIENT Carswell AFB
WELL OR BORING NUMBER MPBG1
PROJECT Bioventing Test system
LOCATION Fuel loading area (POL)
DRILLING FIRM Propre Field services
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME75 HSA
RIG OPERATOR Tom Placek
BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	1½' recovery	light brown silty clay with small to med gravel & nodules. dry to damp. no odors	
	2-4		olive black clay, few small nodules, damp. hydrocarbon odors.	Headspace @3' = 5000 ppm scan = 200 ppm
5	3½-8½	3' recovery	light brown & Black highly plastic clay with small to medium gravel. dry to damp	
			light olive gray fine sandy clay with few small nodules and gravel. damp.	Headspace at 7' = 400-300 ppm scan odors.
	8½-12½'	3½' recovery	Same as above	
10			light gray clayey sand (fine) moist to wet at bottom. Strong odors	sample for BTEX TPH @ 10-11'. OVA scan = 4500 ppm
			H_2O at 12'.	
15				
20				
25				

DRILL LOG

CLIENT Carswell AFB
PROJECT ST14 Bioventing
DRILLING FIRM ~~BAT~~ Profile
DRILLING RIG CME 75 HSA
BEGINNING 6/15/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 6/15/93
GROUNDWATER LEVEL FIRST ENCOUNTERED ______ AND FINAL ______
DATE: ( ) ( )

WELL OR BORING NUMBER MP BG2
LOCATION POL Farm, near warehouse
G.L. ELEVATION ______ LOGGER BRV
RIG OPERATOR Tom Place K

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2	6" recovery	small gravel, loam, sand	
	2-4'	6" recovery	silty clay with some small to medium, dark Brown	OVA scan = 0ppm
5	3½-8½	3.25' recovery	dark olive gray silty clay w/ small to med. gravel. very firm damp.	headspace @ 6' = 0.0 ppm
			light olive gray coarse to fine sandy clay. damp.	OVA scan = 0ppm
10	8½-12	4.0' recovery	light olive gray fine sandy clay, highly plastic and moist. wet @ 12'. No odors.	OVA scan = 0 ppm; sample MPBG2-2 collected 10-10.5'. headspace @ 10' = 0.0 ppm
15			12' TD.	
20				
25				

Appendix C

Chain-of-Custody Forms

Engineering-Science Inc.
7800 Shoal Creek Blvd, Suite 222W
Austin, Texas 78757
512/467-6200 FAX 512/467-7044

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME
AU380.01	Carswell Bioventing System

SAMPLERS (Signatures) Brian Vanderglas [signature]

Kjeldahl

DATE	TIME	MATRIX	SAMPLE IDENTIFICATION	NO. OF CONTAINERS	TRPH (EPA 418.1)	BTEX (EPA SW 8020)	[illegible]	pH	Particle sizing	alkalinity	Nitrogen (TKN)	Phosphorus			REMARKS
5/26/93	1700	SOIL	MPC 6-7		X	X									strong fuel odors,
5/26/93	1700	SOIL	MPC 10-11		X	X	X	X	X	X	X	X			high OVA headspace reading

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Brian Vanderglas	5/27/93	1345	[signature]				
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)

White: laboratory returns with data, **yellow**: laboratory copy, **pink**: sampler copy

Engineering-Science Inc.
7800 Shoal Creek Blvd, Suite 222W
Austin, Texas 78757
512/467-6200 FAX 512/467-7044

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME
AU380.01	Carswell Bioventing

SAMPLERS (Signatures): Brian Vanderglas

DATE	TIME	MATRIX	SAMPLE IDENTIFICATION	NO. OF CONTAINERS	TRPH (EPA 418.1)	BTEX (EPA 8020)	[illegible]	pH	[illegible]	Alkalinity	[illegible]	Nitrogen (TKN)			REMARKS
5/25/93	0940	Soil	Ventwell VW1 5-6	2	x	x									High organic vapor
5/25/93	1020	Soil	Ventwell: ~~W~~ VW1 10-11	2	x	x	x	x	x	x	x	x	x		readings on OVA.
5/25/93	1440	Soil	MPA 9-10	2	x	x	x	x	x	x	x	x	x		
5/26/93	0940	Soil	MPB 9-10	2	x	x	x	x	x	x	x	x			High OVA reading; odors
5/26/93	~~02~~ 1410	Soil	MPBA1 10-11	2	x	x									High OVA Readings (ODORS)

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)
Marc Harder	5/26/1993	1435	[illegible signature]				
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Relinquished by: (Signature)	Date	Time	Received by: (Signature)

White: laboratory returns with data, **yellow:** laboratory copy, **pink:** sampler copy

[redacted] C[redacted] OF [redacted]STO[redacted]RE[redacted]D [redacted] ND[redacted] L[redacted]RAT[redacted]S, [redacted] [redacted] East [redacted]s Blv[redacted]char[redacted] TX [redacted] (21[redacted]8-55[redacted]

Submitted by		Bill to	
Name:	Engineering-Science	Name:	← same
Address:	7800 Shoalcreek Blvd, ste 202W	Address:	
	Austin TX 78757		
Contact:	Brian Vanderglas	Contact:	
Phone:	512/467 6200	Phone:	
Fax:	512/467-7044	Fax:	
		PO/SO #:	AU380.01

Lab use only
Due Date:

RCRA ☐
NPDES ☐

Section / Date

Proj. No.: AU380.01
Project Name: Carswell AFB Bioventing Pilot study

Matrix[1]	Date	Time	Comp	Grab	Identifying Marks	VOA	A/G 1 Lt.	250 ml	P/O	TPH (method EPA 418.1)	BTEX (method EPA SW8020)	soil moisture	pH	particle size analysis	alkalinity	nitrogen (TKN)	phosphorous	Lab. Sample ID
Soil	6/15/93	1025		✓	MPEG2: 10'				2	✓	✓	✓	✓	✓	✓	✓	✓	
Soil	6/15/93	1445		✓	VW2: 10-11				2	✓	✓	✓	✓	✓	✓	✓	✓	
Soil	6/16/93	0830		✓	VW3: 7-8				2	✓	✓	✓	✓	✓	✓	✓	✓	
Soil	6/16/93	0850		✓	VW3: 10-11				2	✓	✓							
Soil	6/16/93	1145		✓	VW4: 10-11				2	✓	✓	✓	✓	✓	✓	✓	✓	

Turn around time ☐ 100% ☐ 50% ☑ Standard Other: ______ Temperature °C: ______

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Brian Vandell	6/16/93	13:50	[illegible]	[illegible]	[illegible]
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Remarks: High organic vapor readings measured on all samples with OVA.

By submitting these samples, you agree to the terms and conditions contained in NDRC's Price Schedule.

[1] Matrix W - Water S - Soil SD - Solid L - Liquid A - Air Bag C - Charcoal tube SL - Sludge O - Oil
[2] Container VOA - 40 ml vial A/G - Amber / Or Glass 1 Liter 250 ml - Glass wide mouth P/O - Plastic or other ______

NDRC cannot accept verbal changes. Please Fax written changes to

Air bill # 32 8141 6019774

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

11325 SUNRISE GOLD CIRCLE, SUITE 'E'
RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

CHAIN OF CUSTODY RECORD

Page 1 of 1

PROJECT # ~~380.~~ AU380.01 PO # Cumulative Brient COLLECTED BY (Signature) Brian Vandiver

REMARKS Send results to Brian Vandiver, 7800 Shoalcreek Blvd, ste 222W Austin, TX 78757 (512) 417-1100 c/o Engineering - Science

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D. #
ST14 - VW	Canister # 12387	6/9/93 1445	TO-3		
ST14 - MPA4	Canister # 12360	6/9/93 1500	TO-3		
ST14 MPC7	Canister # 11442	6/9/93 1518	TO-3		

RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME	RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME
Brian Vandiver 6/11/93 1625	Federal Express		

LAB USE ONLY

SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION

REMARKS

Appendix D

HyperVentilate® Air Permeability Calculation Cards

HyperVentilate© 1991

DATA FROM 7 FOOT DEPTH INTERVAL

Air Permeability Test - Data Analysis (cont.)

1. Enter radial distances of monitoring points → r= 10 (ft) | r= 45 (ft) | r= (ft)
2. Enter measured times and gauge vacuums →
3. Enter (optional):
   a) flowrate 28 (SCFM
   b) screened interval thickness 3.5 (ft)

r= 10 (ft) (min)	(in H2O)	r= 45 (ft) (min)	(in H2O)	r= (ft) (min)	(in H2O)
0	0.00	0	0.20		
.5	.85	.5	.20		
1	2.20	1	.20		
2	3.50	2	.25		
3	4.55	4	.35		
4	6.00	5	.70		
5	7.20	6	1.10		
6	8.40	7	1.35		
8	9.40	8	1.70		
12	11.00	9	2.10		

clear clear clear

-->Calculate<--

k= 30.8204 darcy (A) | k= 93.3873 darcy (A) | k= darcy (A)

k= 13.7283 darcy (B) | k= 86.9432 darcy (B) | k= darcy (B)

Return | Explanation & Statistics | AP8

Air Permeability Test - Data Analysis (cont.)

1. Enter radial distances of monitoring points → r= 10 (ft) | r= 45 (ft) | r= (ft)
2. Enter measured times and gauge vacuums →
3. Enter (optional):
   a) flowrate 28 (SCFM
   b) screened interval thickness 3.5 (ft)

r= 10 (ft) (min)	(in H2O)	r= 45 (ft) (min)	(in H2O)	r= (ft) (min)	(in H2O)
8	9.40	9	2.10		
12	11.00	10	2.25		
22	11.70	12	2.60		
37	12.20	22	3.05		
54	12.80	37	3.50		
92	13.00	92	3.60		
120	13.10	120	3.65		
152	13.10	152	3.65		

clear clear clear

-->Calculate<--

k= 30.8204 darcy (A) | k= 93.3873 darcy (A) | k= darcy (A)

k= 13.7283 darcy (B) | k= 86.9432 darcy (B) | k= darcy (B)

Return | Explanation & Statistics | AP8

HyperVentilate© 1991

DATA FROM 4 FOOT DEPTH INTERVAL

Air Permeability Test - Data Analysis (cont.)

1. Enter radial distances of monitoring points → r= 10 (ft) r= 45 (ft) r= (ft)

2. Enter measured times and gauge vacuums →

3. Enter (optional):

a) flowrate 28 (SCFM

b) screened interval thickness 3.5 (ft)

r = 10 ft

(min)	(in H2O)
0	.05
.5	.00
1	.10
2	.45
3	.75
4	1.00
5	1.40
6	2.30
8	2.75
10	3.90

r = 45 ft

(min)	(in H2O)
0	.20
.5	.15
1	.15
2	.30
4	.55
5	.80
6	1.05
7	1.40
8	1.70
9	2.10

clear clear clear

-->Calculate<--

k= 26.4048 darcy (A) k= 94.2263 darcy (A) k= darcy (A)

k= 2.35569 darcy (B) k= 90.7041 darcy (B) k= darcy (B)

Return Explanation & Statistics AP8

Air Permeability Test - Data Analysis (cont.)

1. Enter radial distances of monitoring points → r= 10 (ft) r= 45 (ft) r= (ft)

2. Enter measured times and gauge vacuums →

3. Enter (optional):

a) flowrate 28 (SCFM

b) screened interval thickness 3.5 (ft)

r = 10 ft

(min)	(in H2O)
8	2.75
10	3.90
12	4.85
22	8.00
37	9.70
54	11.70
92	12.20
120	12.10
152	12.10

r = 45 ft

(min)	(in H2O)
8	1.70
9	2.10
10	2.25
12	2.65
22	3.10
37	3.50
92	3.60
120	3.60
152	3.60

clear clear clear

-->Calculate<--

k= 26.4048 darcy (A) k= 94.2263 darcy (A) k= darcy (A)

k= 2.35569 darcy (B) k= 90.7041 darcy (B) k= darcy (B)

Return Explanation & Statistics AP8

Appendix C

Laboratory Results

Bioventing Pilot Test
Laboratory Results
Site ST14, Fuel Loading Area
Carswell AFB, Texas

Contract F41624-92-D-8036

Prepared for

Air Force Center for
Environmental Excellence
Brooks AFB, Texas

Prepared by

Engineering-Science, Inc.
Austin, Texas

August 1993

CONTENTS

FIGURES

TABLES

BIOVENTING PILOT TEST LABORATORY RESULTS

SITE ST14, FUEL LOADING AREA
CARSWELL AFB, TEXAS

Initial bioventing tests were completed at site ST14 at Carswell Air Force Base (AFB), Texas, during the period May 24, 1993 through June 17, 1993, followed by soil sampling to delineate the extent of contamination of soils at the site. The purpose of this report is to present the analytical results for samples collected during these activities and to provide comments and observations related to the analytical data which may be pertinent to the investigation.

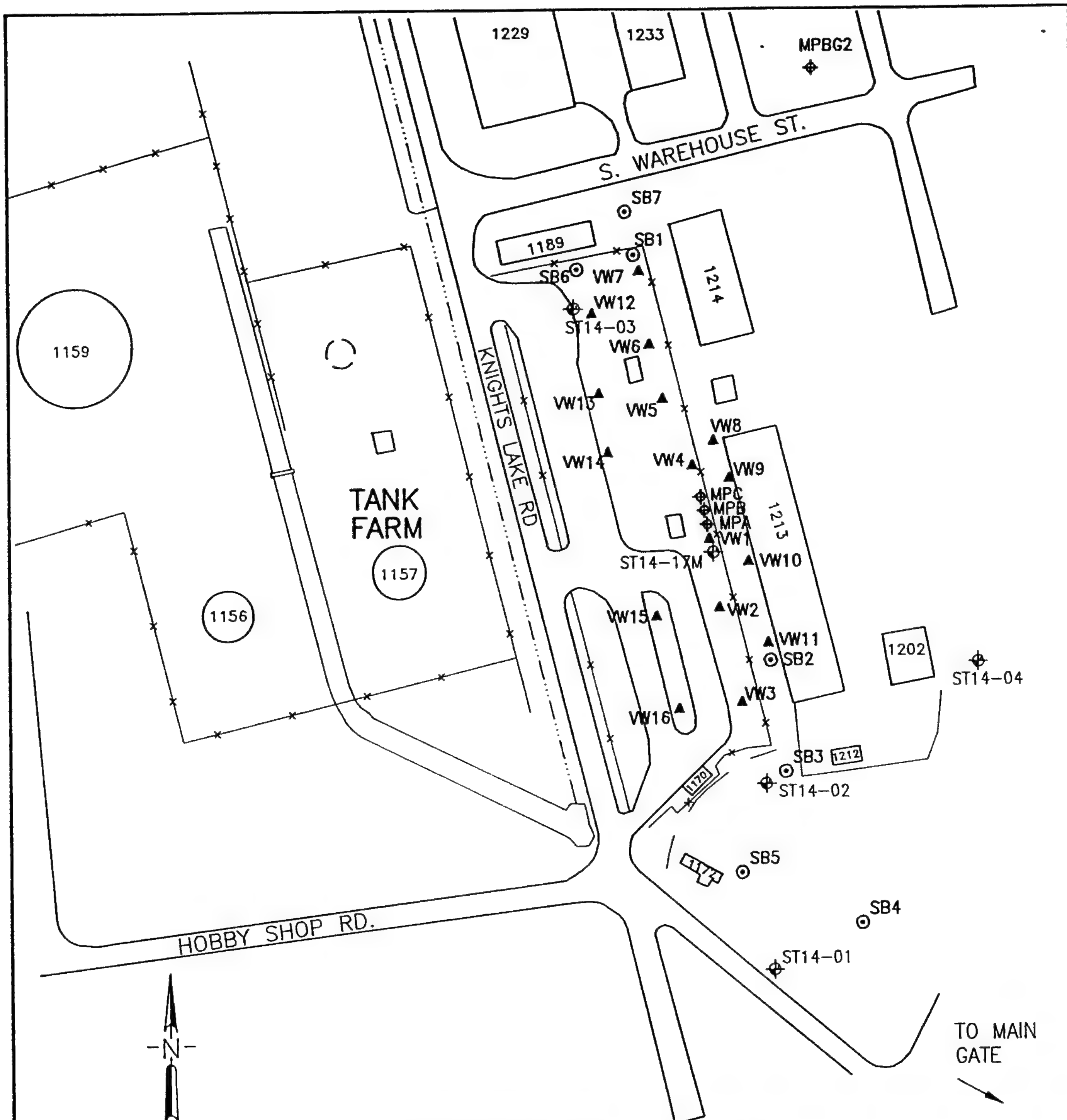
PILOT TEST AND SOILS INVESTIGATION

Soil borings were drilled at twenty-seven locations at the site. In addition to soil borings for sampling only, these borings included the vent well and monitoring points for the pilot test, and locations of vent wells constructed for the full scale bioventing system. The location and types of borings are presented in Figure 1 along with the location of existing monitoring wells.

One or two samples were collected from each boring, for a total of thirty-two soil samples plus two field duplicates. The results of sample analyses are summarized in Table 1 and Table 2. The laboratory reports are presented in the appendix. The sample identifier includes the depth of the 1 foot interval from which the sample was collected (for example, SB2:7-8 is a sample from soil boring 2 at the 7- to 8-foot-depth interval).

REVIEW OF ANALYTICAL RESULTS

Soil samples were sent to NDRC Laboratories, Inc., Richardson, Texas, for analysis. The soils were analyzed for benzene, toluene, ethyl benzene, xylene (BTEX, EPA method 5030/8020), total petroleum hydrocarbons (TPH, EPA 3550/418.1), phosphorus (EPA 3051/6010), total solids (EPA 160.3), total Kjeldahl nitrogen (TKN, EPA 351.3), pH (EPA 9045), alkalinity (EPA 310.1), moisture (ASTM method D2216), and gradation (ASTM D421/D422). In addition to these analysis, the laboratory quality control program included method/prep blanks, matrix spike and matrix spike duplicate recovery and relative percent difference, surrogate recoveries, laboratory duplicates, and laboratory spike recoveries.



0 100 200

SCALE FEET

LEGEND

ST14-02	EXISTING MONITORING WELL
VW1	APPROXIMATE VENT WELL LOCATION
MPA	VAPOR MONITORING POINT
SB4	SOIL BORING LOCATION
	FENCE
1172	BUILDING

ENGINEERING-SCIENCE
DESIGN ✦ RESEARCH ✦ PLANNING
7800 Shoal Creek Blvd.
Suite 222W
Austin, Texas 78757
512-467-6200
Offices in Principal Cities

U.S. Air Force Center for Environmental Excellence

DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93
DRAWN BY:	FIGURE 1
REVIEWED BY: B.R. VANDERGLAS	APPROXIMATE BOREHOLE LOCATIONS AND TYPE
SUBMITTED BY: J.D. HIGHLAND	OF COMPLETION SITE ST14

PLOT SCALE: AS NOTED	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER
DESIGN FILE: SITECARS		CALL ORDER NO.: 0004	1
PLOT DATE: 8/11/93	SHEET OF	CONTRACT NO.: F41624-92-D-8036	

Table 1. Analytical Results: Site ST14
Carswell AFB, Texas

Parameter:	VW1: 5-6	VW1: 10-11	VW2: 10-11	VW3: 7-8	VW3: 10-11	VW4: 10-11	VW5: 7-8	VW5: 10-11	VW6: 9-10
Benzene (μg/kg)	410	270	<200	<2.0	1,000	160	<10	<10	950
Toluene (μg/kg)	580	530	19,000	<2.0	12,000	570	380	440	310
Ethyl benzene (μg/kg)	790	1,400	5,200	<2.0	3,600	1,500	120	<10	980
Xylenes (μg/kg)	4,200	8,800	25,000	4.1	18,000	6,900	410	1,200	1,800
BTEX (μg/kg)	5,980	11,000	49,200	4.1	34,600	9,130	910	1,640	4,040
TRPH (mg/kg)	890	1,500	6,500	<10	4,500	1,900	420	2,600	3,800

Parameter:	VW7: 9-10	VW8: 10-11	VW8: [1] Dup	VW9: 9-10	VW10: 10-11	VW12: 10-11	VW13: 9-10	VW14: 9-10	VW15 11-12
Benzene (μkg)	<1,000	2,000	1,900	200	470	3,800	<2,000	890	<1,000
Toluene (μkg)	19,000	2,600	3,400	3,600	740	2,600	54,000	2,900	10,000
Ethyl benzene (μkg)	3,600	1,200	1,300	910	1,100	2,700	17,000	1,500	3,400
Xylenes (μkg)	4,800	5,000	6,100	4,800	5,200	5,900	52,000	7,100	14,000
BTEX (μg/kg)	27,400	10,800	12,700	9,510	7,510	15,000	123,000	12,400	27,400
TRPH (mg/kg)	5,700	1,900	2,300	1,200	1,500	2,900	1,400	350	3,600

[1] VW8: Dup is a duplicate of VW8:10-11
[2] MPGB1: Also referred to as SB1
[3] VW11: VW11 drilled 5 feet north of SB2
[4] SB4: Dup is a duplicate of SB4:10-11

320SR\AU38001\LABT1

Table 1. (Cont.) Analytical Results: Site St14
Carswell AFB, Texas

	VW16: 9-10	MPA: 9-10	MPB: 9-10	MPC: 6-7	MPC: 10-11	MPBG1: [2] 10-11	MPBG2: 10	SB2: [3] 7-8	SB2: 10-11
Parameter:									
Benzene ($\mu g/kg$)	2,800	1,800	2,800	<500	<200	67,000	<2.0	3.6	53
Tolulene ($\mu g/kg$)	11,000	3,700	4,100	2,000	10,000	<5,000	<2.0	4.8	600
Ethyl benzene ($\mu g/kg$)	6,600	5,300	7,000	3,700	2,600	14,000	<2.0	7.4	<10
Xylenes ($\mu g/kg$)	32,000	36,000	26,000	24,000	17,000	7,700	<2.0	40.0	2,000
BTEX (μ /kg)	52,400	46,800	39,900	29,700	29,600	88,700	<2.0	55.8	2,650
TRPH (mg/kg)	2,600	2,500	2,500	1,100	1,500	9,300	47	<10	5,100

	SB3: 9-10	SB4: 7-8	SB4: 10-11	SB4: [4] Dup	SB5: 10-11	SB6: 9-10	SB7: 11-12
Parameter:							
Benzene ($\mu g/kg$)	5,400	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Tolulene ($\mu g/kg$)	15,000	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ethyl benzene ($\mu g/kg$)	4,100	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Xylenes ($\mu g/kg$)	24,000	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
BTEX (μ /kg)	48,500	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
TRPH (mg/kg)	1,400	<10	<10	<10	<10	34	<10

[1] VW8: Dup is a duplicate of VW8:10-11
[2] MPGB1: Also referred to as SB1
[3] VW11: VW11 drilled 5 feet north of SB2
[4] SB4: Dup is a duplicate of SB4:10-11

320SR\AU38001\LABT1

Table 2. Soil Venting Characteristics: ST14, Carswell AFB

Sample Number	VW1: 5–6	VW1: 10–11	MPA: 9–10	MPB: 9–10	MPBG1: 10–11	MPC: 6–7	MPC: 10–11	MPBG2: 10'	VW2: 10–11	VW3: 7–8	VW3: 10–11	VW4: 10–11	VW5: 7–8	VW5: 10–11	VW6: 9–10	VW7: 9–10	VW8: 9–10
Parameter:																	
Gradation Report																	
Gravel and Coarse Sand (> 2.00 mm) (%)	NA	< 0.1	< 0.1	< 0.1	NA	NA	< 0.1	< 0.1	< 0.1	< 0.1	NA	< 0.1	< 0.1	NA	< 0.1	< 0.1	< 0.1
Medium and Fine Sand (0.075 to 2.00 mm) (%)	NA	20.5	7.5	6.0	NA	NA	38.6	24.5	37.9	9.7	NA	13.9	17.6	NA	66.2	52.1	9.9
Silt (0.005 to 0.075 mm) (%)	NA	60.6	65.8	60.4	NA	NA	49.5	57.0	48.5	57.6	NA	61.4	52.8	NA	24.9	35.6	63.1
Clay/Colloids (< 0.005 mm) (%)	NA	18.9	26.8	33.6	NA	NA	11.9	18.5	13.6	32.7	NA	24.7	29.6	NA	8.9	12.3	27.0
Phosphorus (mg/Kg)	NA	97.2	114	96.2	NA	NA	73.1	58.8	62.4	133	NA	89.0	211	NA	81.4	67.7	96.6
Alkalinity (mg/Kg CaCO3)	NA	35	350	450	NA	NA	250	1550	206	412	NA	515	515	NA	464	206	361
Moisture (%)	NA	15.3	25.3	23	NA	NA	16.3	15.7	8.2	12.7	NA	15.0	18.8	NA	15.4	14.5	22.1
Nitrogen, Total Kjeldahl (mg/Kg)	NA	350	280	224	NA	NA	420	238	224	462	NA	336	714	NA	308	420	504
pH	NA	8.9	8.6	9	NA	NA	8.9	8.3	8.6	8.2	NA	8.4	8.5	NA	8.6	9.5	8.5
Total solids (%)	81.4	84.7	74.7	76.9	85.1	78.9	83.7	84.3	91.8	87.3	87.6	85.0	81.2	85.7	84.6	85.5	77.9

Sample Number	VW8: dup	VW9: 9–10	SB2: 7–8	SB2: 10–11	SB3: 9–10	SB4: 7–8	SB4: 10–11	SB4: Dup	SB5: 10–11	VW10: 10–11	SB6: 9–10	VW12: 10–11	VW13: 9–10	VW14: 9–10	VW15: 11–12	VW16: 9–10	SB7: 11–12
Parameter:																	
Gradation Report																	
Gravel and Coarse Sand (> 2.00 mm) (%)	< 0.1	< 0.1	NA	NA	NA	NA	NA	NA	NA	< 0.1	NA	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	NA
Medium and Fine Sand (0.075 to 2.00 mm) (%)	9.5	13.8	NA	NA	NA	NA	NA	NA	NA	6.8	NA	31.8	81.0	4.6	49.3	55.4	NA
Silt (0.005 to 0.075 mm) (%)	61.4	53.7	NA	NA	NA	NA	NA	NA	NA	65.1	NA	51.4	14.2	67.4	38.5	35.3	NA
Clay/Colloids (< 0.005 mm) (%)	29.1	32.5	NA	NA	NA	NA	NA	NA	NA	28.1	NA	16.9	4.8	28.0	12.1	9.3	NA
Phosphorus (mg/Kg)	97.7	98.4	NA	NA	NA	NA	NA	NA	NA	88.3	NA	76.9	73.5	90.9	118	105	NA
Alkalinity (mg/Kg CaCO3)	412	309	NA	NA	NA	NA	NA	NA	NA	790	NA	1310	1350	490	1260	1360	NA
Moisture (%)	21.1	21.7	NA	NA	NA	NA	NA	NA	NA	23.7	NA	14.0	16.2	19.8	13.4	14.0	NA
Nitrogen, Total Kjeldahl (mg/Kg)	378	392	NA	NA	NA	NA	NA	NA	NA	294	NA	280	140	350	252	280	NA
pH	8.7	8.6	NA	NA	NA	NA	NA	NA	NA	8.8	NA	9.0	8.8	8.9	9.1	8.6	NA
Total solids (%)	78.9	78.3	85.1	83.4	82.6	84.3	87.7	87.7	84.5	74.8	74.9	86.0	83.8	80.2	86.6	86.0	88.4

The laboratory analytical reports and quality control reports were examined for comparison to quality assurance criteria described in the applicable method. Holding times, blank contamination, precision, accuracy, representativeness, comparability, and completeness were all in compliance except for the holding time for sample VW1:5-6. This sample was 1 day beyond the holding time at the time of the analysis for total solids. Sample results for VW1:5-6 total solids should be considered estimated. All other data provided by the laboratory meet the quality assurance criteria.

Appendix

AIR TOXICS LTD.

SAMPLE NAME: ST14-VW
ID#: 9306090-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6061407		Date of Collection: 6/9/93	
Dil. Factor:	2100		Date of Analysis: 6/14/93	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	2.1	6.6	Not Detected	Not Detected
Toluene	2.1	7.7	Not Detected	Not Detected
Ethyl Benzene	2.1	8.9	6.4	27
Total Xylenes	2.1	8.9	19	81

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6061407		Date of Collection: 6/9/93	
Dil. Factor:	2100		Date of Analysis: 6/14/93	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH*	21	130	23000	140000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: ST14-MPA4
ID#: 9306090-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6061408		Date of Collection: 6/9/93	
Dil. Factor:	1100		Date of Analysis: 6/14/93	
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.1	3.4	Not Detected	Not Detected
Toluene	1.1	4.0	Not Detected	Not Detected
Ethyl Benzene	1.1	4.7	4.4	19
Total Xylenes	1.1	4.7	11	47

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6061408		Date of Collection: 6/9/93	
Dil. Factor:	1100		Date of Analysis: 6/14/93	
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	11	69	21000	130000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: ST14-MPC7
ID#: 9306090-03A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6061409		Date of Collection: 6/9/93	
Dil. Factor:	1100		Date of Analysis: 6/14/93	
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.1	3.4	Not Detected	Not Detected
Toluene	1.1	4.0	Not Detected	Not Detected
Ethyl Benzene	1.1	4.7	7.9	33
Total Xylenes	1.1	4.7	21	89

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6061409		Date of Collection: 6/9/93	
Dil. Factor:	1100		Date of Analysis: 6/14/93	
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	11	69	28000	170000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9306090-04A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6061403		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 6/14/93	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6061403		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 6/14/93	

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.010	0.062	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

Container Type: NA

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-1
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (6-7)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 250

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	500 µg/Kg	< 500 µg/Kg
Toluene	500 µg/Kg	2000 µg/Kg
Ethyl benzene	500 µg/Kg	3700 µg/Kg
Xylenes	500 µg/Kg	24000 µg/Kg
BTEX (total)		29700 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	115 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. David R Godwin VZ
David R. Godwin, Ph.D.
Chief Executive Officer

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-2
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 2-JUN-1993
DILUTION FACTOR : 100

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	200 µg/Kg	< 200 µg/Kg
Toluene	200 µg/Kg	10000 µg/Kg
Ethyl benzene	200 µg/Kg	2600 µg/Kg
Xylenes	200 µg/Kg	17000 µg/Kg
BTEX (total)		29600 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	101 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. David R. Godwin VZ
David R. Godwin, Ph.D.
Chief Executive Officer

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-1
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (6-7)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 5-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1100 mg/Kg

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DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-2
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 5-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1500 mg/Kg

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DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-2
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	73.1 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 28-MAY-1993 by CCM
Analyzed using EPA 6010 on 2-JUN-1993 by KJS

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DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-2
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 4-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	38.6 %
Silt (0.005 to 0.075 mm)	0.1 %	49.5 %
Clay/Colloids (< 0.005 mm)	0.1 %	11.9 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-1
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (6-7)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	78.9 %
Analyzed using EPA 160.3 on 1-JUN-1993 by KOB		

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DATE RECEIVED : 27-MAY-1993

REPORT NUMBER : D93-6140-2
REPORT DATE : 11-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPC (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	250 mg/KgCaCO3
Analyzed using EPA 310.1 on 27-MAY-1993 by BAF		
Moisture (Oven)	0.01 %	16.3 %
Analyzed using ASTM D2216 on 27-MAY-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	420 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-MAY-1993 by MKS		
pH		8.9
Analyzed using EPA 9045 on 28-MAY-1993 by JCH		
Total Solids	0.01 %	83.7 %
Analyzed using EPA 160.3 on 27-MAY-1993 by RJS		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-1
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (5-6)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 27-MAY-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	410 µg/Kg
Toluene	2.0 µg/Kg	580 µg/Kg
Ethyl benzene	2.0 µg/Kg	790 µg/Kg
Xylenes	2.0 µg/Kg	4200 µg/Kg
BTEX (total)		5980 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	80.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

David R. Godwin RZ

NDRC Laboratories, Inc.______________________
David R. Godwin, Ph.D.
Chief Executive Officer

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-2
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 28-MAY-1993
DILUTION FACTOR : 100

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	200 µg/Kg	270 µg/Kg
Toluene	200 µg/Kg	530 µg/Kg
Ethyl benzene	200 µg/Kg	1400 µg/Kg
Xylenes	200 µg/Kg	8800 µg/Kg
BTEX (total)		11000 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	117 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-3
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPA (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 500

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	1000 µg/Kg	1800 µg/Kg
Toluene	1000 µg/Kg	3700 µg/Kg
Ethyl benzene	1000 µg/Kg	5300 µg/Kg
Xylenes	1000 µg/Kg	36000 µg/Kg
BTEX (total)		46800 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	111 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-4
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPB (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 28-MAY-1993
DILUTION FACTOR : 1000

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2000 µg/Kg	2800 µg/Kg
Toluene	2000 µg/Kg	4100 µg/Kg
Ethyl benzene	2000 µg/Kg	7000 µg/Kg
Xylenes	2000 µg/Kg	26000 µg/Kg
BTEX (total)		39900 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	109 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. David R. Godwin VZ

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-5
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 2500

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	5000 µg/Kg	67000 µg/Kg
Toluene	5000 µg/Kg	< 5000 µg/Kg
Ethyl benzene	5000 µg/Kg	14000 µg/Kg
Xylenes	5000 µg/Kg	7700 µg/Kg
BTEX (total)		88700 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	106 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. David R. Godwin VZ

David R. Godwin, Ph.D.
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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-1
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (5-6)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	890 mg/Kg

David R. Godwin RZ

NDRC Laboratories, Inc. David R. Godwin, Ph.D.
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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-2
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1500 mg/Kg

NDRC Laboratories, Inc. David R. Godwin RZ

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-3
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPA (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	2500 mg/Kg

NDRC Laboratories, Inc. David R. Godwin RZ

David R. Godwin, Ph.D.
Chief Executive Officer

NDRC LABORATORIES, INC.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-4
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPB (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	2500 mg/Kg

NDRC Laboratories, Inc. David R. Godwin VZ
David R. Godwin, Ph.D.
Chief Executive Officer

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-5
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 1-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	9300 mg/Kg

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-2
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 4-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	20.5 %
Silt (0.005 to 0.075 mm)	0.1 %	60.6 %
Clay/Colloids (< 0.005 mm)	0.1 %	18.9 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-3
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPA (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 4-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	7.5 %
Silt (0.005 to 0.075 mm)	0.1 %	65.8 %
Clay/Colloids (< 0.005 mm)	0.1 %	26.8 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-4
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPB (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 4-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	6.0 %
Silt (0.005 to 0.075 mm)	0.1 %	60.4 %
Clay/Colloids (< 0.005 mm)	0.1 %	33.6 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-2
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	97.2 mg/Kg
Dilution Factor : 1 Prepared using EPA 3051 on 28-MAY-1993 by CCM Analyzed using EPA 6010 on 2-JUN-1993 by KJS		

David R. Godwin RZ

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-3
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPA (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	114 mg/Kg
Dilution Factor : 1 Prepared using EPA 3051 on 28-MAY-1993 by CCM Analyzed using EPA 6010 on 2-JUN-1993 by KJS		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-4
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPB (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	96.2 mg/Kg
Dilution Factor : 1 Prepared using EPA 3051 on 28-MAY-1993 by CCM Analyzed using EPA 6010 on 2-JUN-1993 by KJS		

NDRC Laboratories, Inc. David R. Godwin RZ
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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-1
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (5-6)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	81.4 %
Analyzed using EPA 160.3 on 1-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-2
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : Ventwell: VW1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	350 mg/KgCaCO3
Analyzed using EPA 310.1 on 27-MAY-1993 by BAF		
Moisture (Oven)	0.01 %	15.3 %
Analyzed using ASTM D2216 on 27-MAY-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	350 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 27-MAY-1993 by BAF		
pH		8.9
Analyzed using EPA 9045 on 27-MAY-1993 by MKS		
Total Solids	0.01 %	84.7 %
Analyzed using EPA 160.3 on 27-MAY-1993 by RJS		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-3
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPA (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 25-MAY-1993

MISCELLANEOUS ANALYSES				
TEST REQUESTED	DETECTION LIMIT		RESULTS	
Alkalinity	0.1	mg/KgCaCO3	350	mg/KgCaCO3
Analyzed using EPA 310.1 on 27-MAY-1993 by BAF				
Moisture (Oven)	0.01	%	25.3	%
Analyzed using ASTM D2216 on 27-MAY-1993 by RJS				
Nitrogen, Total Kjeldahl	10.0	mg/Kg	280	mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 27-MAY-1993 by BAF				
pH			8.6	
Analyzed using EPA 9045 on 27-MAY-1993 by MKS				
Total Solids	0.01	%	74.7	%
Analyzed using EPA 160.3 on 27-MAY-1993 by RJS				

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-4
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPB (9-10)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	450 mg/KgCaCO3
Analyzed using EPA 310.1 on 27-MAY-1993 by BAF		
Moisture (Oven)	0.01 %	23.0 %
Analyzed using ASTM D2216 on 27-MAY-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	224 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 27-MAY-1993 by BAF		
pH		9.0
Analyzed using EPA 9045 on 27-MAY-1993 by MKS		
Total Solids	0.01 %	76.9 %
Analyzed using EPA 160.3 on 27-MAY-1993 by RJS		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 26-MAY-1993

REPORT NUMBER : D93-6107-5
REPORT DATE : 8-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG1 (10-11)
PROJECT : AU380.01 Carswell Bioventing
DATE SAMPLED : 26-MAY-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	85.1 %
Analyzed using EPA 160.3 on 1-JUN-1993 by KOB		

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Chief Executive Officer

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG2:10'
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 17-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	115 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VJ

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW2:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 17-JUN-1993
DILUTION FACTOR : 100

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	200 µg/Kg	< 200 µg/Kg
Toluene	200 µg/Kg	19000 µg/Kg
Ethyl benzene	200 µg/Kg	5200 µg/Kg
Xylenes	200 µg/Kg	25000 µg/Kg
BTEX (total)		49200 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	76.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 18-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	4.1 µg/Kg
BTEX (total)		4.1 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	103 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-4
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 17-JUN-1993
DILUTION FACTOR : 100

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	200 µg/Kg	1000 µg/Kg
Toluene	200 µg/Kg	12000 µg/Kg
Ethyl benzene	200 µg/Kg	3600 µg/Kg
Xylenes	200 µg/Kg	18000 µg/Kg
BTEX (total)		34600 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	74.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW4:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 18-JUN-1993
DILUTION FACTOR : 25

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	50 µg/Kg	160 µg/Kg
Toluene	50 µg/Kg	570 µg/Kg
Ethyl benzene	50 µg/Kg	1500 µg/Kg
Xylenes	50 µg/Kg	6900 µg/Kg
BTEX (total)		9130 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	119 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VJ
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW4:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 24-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	13.9 %
Silt (0.005 to 0.075 mm)	0.1 %	61.4 %
Clay/Colloids (< 0.005 mm)	0.1 %	24.7 %

NDRC Laboratories, Inc. Martin Jeffus / VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 24-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	9.7 %
Silt (0.005 to 0.075 mm)	0.1 %	57.6 %
Clay/Colloids (< 0.005 mm)	0.1 %	32.7 %

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW2:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 24-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	37.9 %
Silt (0.005 to 0.075 mm)	0.1 %	48.5 %
Clay/Colloids (< 0.005 mm)	0.1 %	13.6 %

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG2:10'
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 24-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	24.5 %
Silt (0.005 to 0.075 mm)	0.1 %	57.0 %
Clay/Colloids (< 0.005 mm)	0.1 %	18.5 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG2:10'
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	47 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW2:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	6500 mg/Kg

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-4
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	4500 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW4:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1900 mg/Kg

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG2:10'
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	85.8 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 17-JUN-1993 by CCM
Analyzed using EPA 6010 on 18-JUN-1993 by KJS

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW2:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	62.4 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 17-JUN-1993 by CCM
Analyzed using EPA 6010 on 18-JUN-1993 by KJS

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	133 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 17-JUN-1993 by CCM
Analyzed using EPA 6010 on 18-JUN-1993 by KJS

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General Manager

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DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW4:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	89.0 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 17-JUN-1993 by CCM
Analyzed using EPA 6010 on 18-JUN-1993 by KJS

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : MPBG2:10'
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	1550 mg/KgCaCO3
Analyzed using EPA 310.1 on 17-JUN-1993 by BAF		
Moisture (Oven)	0.01 %	15.7 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	238 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.3
Analyzed using EPA 9045 on 17-JUN-1993 by BAF		
Total Solids	0.01 %	84.3 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW2:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 15-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	206 mg/KgCaCO3
Analyzed using EPA 310.1 on 17-JUN-1993 by BAF		
Moisture (Oven)	0.01 %	8.20 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	224 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.6
Analyzed using EPA 9045 on 17-JUN-1993 by BAF		
Total Solids	0.01 %	91.8 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	412 mg/KgCaCO3
Analyzed using EPA 310.1 on 17-JUN-1993 by BAF		
Moisture (Oven)	0.01 %	12.7 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	462 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.2
Analyzed using EPA 9045 on 17-JUN-1993 by BAF		
Total Solids	0.01 %	87.3 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-4
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW3:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	87.6 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 16-JUN-1993

REPORT NUMBER : D93-6946-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW4:10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	515 mg/KgCaCO3
Analyzed using EPA 310.1 on 17-JUN-1993 by BAF		
Moisture (Oven)	0.01 %	15.0 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	336 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.4
Analyzed using EPA 9045 on 17-JUN-1993 by BAF		
Total Solids	0.01 %	85.0 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB3-9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 25-JUN-1993
DILUTION FACTOR : 250

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	500 µg/Kg	5400 µg/Kg
Toluene	500 µg/Kg	15000 µg/Kg
Ethyl benzene	500 µg/Kg	4100 µg/Kg
Xylenes	500 µg/Kg	24000 µg/Kg
BTEX (total)		48500 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	88.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-7-8
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	106 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 25-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	117 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-4
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-Dup
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 25-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	117 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB5-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	115 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-6
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-VW10-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 25

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	50 µg/Kg	470 µg/Kg
Toluene	50 µg/Kg	740 µg/Kg
Ethyl benzene	50 µg/Kg	1100 µg/Kg
Xylenes	50 µg/Kg	5200 µg/Kg
BTEX (total)		7510 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	71.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-7
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB6-9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	113 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VZ
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB3-9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1400 mg/Kg

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-7-8
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-4
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-Dup
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB5-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-6
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-VW10-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1500 mg/Kg

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-7
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB6-9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	34 mg/Kg

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-1
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB3-9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	82.6 %
Analyzed using EPA 160.3 on 25-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-2
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-7-8
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	84.3 %
Analyzed using EPA 160.3 on 25-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-3
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	87.7 %
Analyzed using EPA 160.3 on 25-JUN-1993 by KOB		

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-4
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB4-Dup
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	87.7 %
Analyzed using EPA 160.3 on 25-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-5
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-SB5-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	84.5 %
Analyzed using EPA 160.3 on 25-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-6
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-VW10-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	790 mg/KgCaCO3
Analyzed using EPA 310.1 on 28-JUN-1993 by BWB		
Moisture (Oven)	0.01 %	23.7 %
Analyzed using ASTM D2216 on 23-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	294 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-JUN-1993 by MKS		
pH		8.8
Analyzed using EPA 9045 on 24-JUN-1993 by BWB		
Total Solids	0.01 %	74.8 %
Analyzed using EPA 160.3 on 23-JUN-1993 by RJS		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-7
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB6-9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	74.9 %
Analyzed using EPA 160.3 on 25-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-6
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-VW10-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	88.3 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 23-JUN-1993 by CCM
Analyzed using EPA 6010 on 25-JUN-1993 by KJS

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 22-JUN-1993

REPORT NUMBER : D93-7177-6
REPORT DATE : 1-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : ST14-VW10-10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 21-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 30-JUN-1993

GRADATION REPORT

TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	6.8 %
Silt (0.005 to 0.075 mm)	0.1 %	65.1 %
Clay/Colloids (< 0.005 mm)	0.1 %	28.1 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-1
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 21-JUN-1993
DILUTION FACTOR : 5

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	10.0 µg/Kg	< 10.0 µg/Kg
Toluene	10.0 µg/Kg	380 µg/Kg
Ethyl benzene	10.0 µg/Kg	120 µg/Kg
Xylenes	10.0 µg/Kg	410 µg/Kg
BTEX (total)		910 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	82.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993
REPORT NUMBER : D93-7074-2
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 21-JUN-1993
DILUTION FACTOR : 5

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	10.0 µg/Kg	< 10.0 µg/Kg
Toluene	10.0 µg/Kg	440 µg/Kg
Ethyl benzene	10.0 µg/Kg	< 10.0 µg/Kg
Xylenes	10.0 µg/Kg	1200 µg/Kg
BTEX (total)		1640 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	114 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL
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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-3
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW6: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 21-JUN-1993
DILUTION FACTOR : 50

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	100 µg/Kg	950 µg/Kg
Toluene	100 µg/Kg	310 µg/Kg
Ethyl benzene	100 µg/Kg	980 µg/Kg
Xylenes	100 µg/Kg	1800 µg/Kg
BTEX (total)		4040 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	81.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-4
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW7: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : RJD
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 500

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	1000 µg/Kg	< 1000 µg/Kg
Toluene	1000 µg/Kg	19000 µg/Kg
Ethyl benzene	1000 µg/Kg	3600 µg/Kg
Xylenes	1000 µg/Kg	4800 µg/Kg
BTEX (total)		27400 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	71.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

NDRC LABORATORIES, INC.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-5
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 22-JUN-1993
DILUTION FACTOR : 50

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	100 µg/Kg	2000 µg/Kg
Toluene	100 µg/Kg	2600 µg/Kg
Ethyl benzene	100 µg/Kg	1200 µg/Kg
Xylenes	100 µg/Kg	5000 µg/Kg
BTEX (total)		10800 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	122 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-6
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: Duplicate
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 22-JUN-1993
DILUTION FACTOR : 50

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	100 µg/Kg	1900 µg/Kg
Toluene	100 µg/Kg	3400 µg/Kg
Ethyl benzene	100 µg/Kg	1300 µg/Kg
Xylenes	100 µg/Kg	6100 µg/Kg
BTEX (total)		12700 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	82.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-7
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW9: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 23-JUN-1993
DILUTION FACTOR : 25

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	50 µg/Kg	200 µg/Kg
Toluene	50 µg/Kg	3600 µg/Kg
Ethyl benzene	50 µg/Kg	910 µg/Kg
Xyienes	50 µg/Kg	4800 µg/Kg
BTEX (total)		9510 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	86.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-8
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB2: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 22-JUN-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	3.6 µg/Kg
Toluene	2.0 µg/Kg	4.8 µg/Kg
Ethyl benzene	2.0 µg/Kg	7.4 µg/Kg
Xylenes	2.0 µg/Kg	40.0 µg/Kg
BTEX (total)		55.8 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	109 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-9
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB2: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 21-JUN-1993
DILUTION FACTOR : 5

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	10.0 µg/Kg	53.0 µg/Kg
Toluene	10.0 µg/Kg	600 µg/Kg
Ethyl benzene	10.0 µg/Kg	< 10.0 µg/Kg
Xylenes	10.0 µg/Kg	2000 µg/Kg
BTEX (total)		2650 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	71.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-1
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 25-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	17.6 %
Silt (0.005 to 0.075 mm)	0.1 %	52.8 %
Clay/Colloids (< 0.005 mm)	0.1 %	29.6 %

NDRC Laboratories, Inc. Martin Jeffus VZ

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-3
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW6: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 25-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	66.2 %
Silt (0.005 to 0.075 mm)	0.1 %	24.9 %
Clay/Colloids (< 0.005 mm)	0.1 %	8.9 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-4
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW7: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 25-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	52.1 %
Silt (0.005 to 0.075 mm)	0.1 %	35.6 %
Clay/Colloids (< 0.005 mm)	0.1 %	12.3 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-5
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 25-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	9.9 %
Silt (0.005 to 0.075 mm)	0.1 %	63.1 %
Clay/Colloids (< 0.005 mm)	0.1 %	27.0 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-6
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: Duplicate
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 25-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	9.5 %
Silt (0.005 to 0.075 mm)	0.1 %	61.4 %
Clay/Colloids (< 0.005 mm)	0.1 %	29.1 %

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-7
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW9: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 25-JUN-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	13.8 %
Silt (0.005 to 0.075 mm)	0.1 %	53.7 %
Clay/Colloids (< 0.005 mm)	0.1 %	32.5 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-1
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	420 mg/Kg

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-2
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	2600 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-3
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW6: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	3800 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-4
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW7: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	5700 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-5
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1900 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-6
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: Duplicate
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	2300 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-7
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW9: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1200 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-8
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB2: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-9
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB2: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 29-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	5100 mg/Kg

NDRC Laboratories, Inc. Martin Jeffus VZ
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-1
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	515 mg/KgCaCO3
Analyzed using EPA 310.1 on 18-JUN-1993 by JCH		
Moisture (Oven)	0.01 %	18.8 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	714 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.5
Analyzed using EPA 9045 on 23-JUN-1993 by BWB		
Total Solids	0.01 %	81.2 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-2
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	85.7 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-3
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW6: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	464 mg/KgCaCO3
Analyzed using EPA 310.1 on 18-JUN-1993 by JCH		
Moisture (Oven)	0.01 %	15.4 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	308 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.6
Analyzed using EPA 9045 on 23-JUN-1993 by BWB		
Total Solids	0.01 %	84.6 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-4
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW7: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	206 mg/KgCaCO3
Analyzed using EPA 310.1 on 18-JUN-1993 by JCH		
Moisture (Oven)	0.01 %	14.5 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	420 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		9.5
Analyzed using EPA 9045 on 25-JUN-1993 by BWB		
Total Solids	0.01 %	85.5 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-5
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	361 mg/KgCaCO3
Analyzed using EPA 310.1 on 18-JUN-1993 by JCH		
Moisture (Oven)	0.01 %	22.1 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	504 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.5
Analyzed using EPA 9045 on 23-JUN-1993 by BWB		
Total Solids	0.01 %	77.9 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-6
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: Duplicate
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	412 mg/KgCaCO3
Analyzed using EPA 310.1 on 18-JUN-1993 by JCH		
Moisture (Oven)	0.01 %	21.1 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	378 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.7
Analyzed using EPA 9045 on 23-JUN-1993 by BWB		
Total Solids	0.01 %	78.9 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-7
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW9: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	309 mg/KgCaCO3
Analyzed using EPA 310.1 on 18-JUN-1993 by JCH		
Moisture (Oven)	0.01 %	21.7 %
Analyzed using ASTM D2216 on 22-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	392 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 25-JUN-1993 by MKS		
pH		8.6
Analyzed using EPA 9045 on 23-JUN-1993 by BWB		
Total Solids	0.01 %	78.3 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-8
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB2: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	85.1 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-9
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB2: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	83.4 %
Analyzed using EPA 160.3 on 21-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-1
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW5: 7-8
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 16-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	211 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 21-JUN-1993 by CCM
Analyzed using EPA 6010 on 23-JUN-1993 by KJS

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-3
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW6: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	81.4 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 21-JUN-1993 by CCM
Analyzed using EPA 6010 on 23-JUN-1993 by KJS

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-4
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW7: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	67.7 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 21-JUN-1993 by CCM
Analyzed using EPA 6010 on 23-JUN-1993 by KJS

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-5
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: 10-11
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	96.6 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 21-JUN-1993 by CCM
Analyzed using EPA 6010 on 23-JUN-1993 by KJS

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-6
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW8: Duplicate
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 17-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	97.7 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 21-JUN-1993 by CCM
Analyzed using EPA 6010 on 23-JUN-1993 by KJS

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 18-JUN-1993

REPORT NUMBER : D93-7074-7
REPORT DATE : 29-JUN-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW9: 9-10
: Bioventing Pilot Study
PROJECT : AU380.01 Carswell AFB
DATE SAMPLED : 18-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	98.4 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 21-JUN-1993 by CCM
Analyzed using EPA 6010 on 23-JUN-1993 by KJS

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General Manager .

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-1
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW12: 10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 28-JUN-1993
DILUTION FACTOR : 250

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	500 µg/Kg	3800 µg/Kg
Toluene	500 µg/Kg	2600 µg/Kg
Ethyl benzene	500 µg/Kg	2700 µg/Kg
Xylenes	500 µg/Kg	5900 µg/Kg
BTEX (total)		15000 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	103 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-2
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW13: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : RJD
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 1000

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2000 µg/Kg	< 2000 µg/Kg
Toluene	2000 µg/Kg	54000 µg/Kg
Ethyl benzene	2000 µg/Kg	17000 µg/Kg
Xylenes	2000 µg/Kg	52000 µg/Kg
BTEX (total)		123000 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	90.0 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-3
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW14: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : RJD
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 50

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	100 µg/Kg	890 µg/Kg
Toluene	100 µg/Kg	2900 µg/Kg
Ethyl benzene	100 µg/Kg	1500 µg/Kg
Xylenes	100 µg/Kg	7100 µg/Kg
BTEX (total)		12400 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	121 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-4
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW15: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : PSS
ANALYZED ON : 28-JUN-1993
DILUTION FACTOR : 500

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	1000 µg/Kg	< 1000 µg/Kg
Toluene	1000 µg/Kg	10000 µg/Kg
Ethyl benzene	1000 µg/Kg	3400 µg/Kg
Xylenes	1000 µg/Kg	14000 µg/Kg
BTEX (total)		27400 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	115 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-5
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW16: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : RJD
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 500

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	1000 µg/Kg	2800 µg/Kg
Toluene	1000 µg/Kg	11000 µg/Kg
Ethyl benzene	1000 µg/Kg	6600 µg/Kg
Xylenes	1000 µg/Kg	32000 µg/Kg
BTEX (total)		52400 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	125 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-6
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB7: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 24-JUN-1993
ANALYSIS METHOD : EPA 8020
ANALYZED BY : VLH
ANALYZED ON : 1-JUL-1993
DILUTION FACTOR : 1

BTEX ANALYSIS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Benzene	2.0 µg/Kg	< 2.0 µg/Kg
Toluene	2.0 µg/Kg	< 2.0 µg/Kg
Ethyl benzene	2.0 µg/Kg	< 2.0 µg/Kg
Xylenes	2.0 µg/Kg	< 2.0 µg/Kg
BTEX (total)		< 2.0 µg/Kg #

QUALITY CONTROL DATA		
SURROGATE COMPOUND	SPIKE LEVEL	SPIKE RECOVERED
Bromofluorobenzene(SS)	50.0 µg/Kg	119 %

Based upon Good Laboratory Practice, the result is rounded to the appropriate number of significant figures.

NDRC Laboratories, Inc. Martin Jeffus VL

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-1
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW12: 10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 2-JUL-1993

GRADATION REPORT

TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	31.8 %
Silt (0.005 to 0.075 mm)	0.1 %	51.4 %
Clay/Colloids (< 0.005 mm)	0.1 %	16.9 %

NDRC Laboratories, Inc. Martin Jeffus VZ
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-2
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW13: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 2-JUL-1993

GRADATION REPORT

TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	81.0 %
Silt (0.005 to 0.075 mm)	0.1 %	14.2 %
Clay/Colloids (< 0.005 mm)	0.1 %	4.8 %

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-3
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW14: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 2-JUL-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	4.6 %
Silt (0.005 to 0.075 mm)	0.1 %	67.4 %
Clay/Colloids (< 0.005 mm)	0.1 %	28.0 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-4
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW15: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 2-JUL-1993

GRADATION REPORT		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	49.3 %
Silt (0.005 to 0.075 mm)	0.1 %	38.5 %
Clay/Colloids (< 0.005 mm)	0.1 %	12.1 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-5
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW16: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : ASTM D421/D422
ANALYZED BY : NJK
ANALYZED ON : 2-JUL-1993

GRADATION REPORT

TEST REQUESTED	DETECTION LIMIT	RESULTS
Gravel & Coarse Sand (> 2.00 mm)	0.1 %	< 0.1 %
Medium & Fine Sand (0.075 to 2.00 mm)	0.1 %	55.4 %
Silt (0.005 to 0.075 mm)	0.1 %	35.3 %
Clay/Colloids (< 0.005 mm)	0.1 %	9.3 %

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-1
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW12: 10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	2900 mg/Kg

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Martin Jeffus
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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-2
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW13: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	1400 mg/Kg

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-3
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW14: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	350 mg/Kg

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-4
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW15: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	3600 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-5
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW16: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 10

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	100 mg/Kg	2600 mg/Kg

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-6
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB7: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 24-JUN-1993
ANALYSIS METHOD : EPA 418.1
ANALYZED BY : CDR
ANALYZED ON : 30-JUN-1993
DILUTION FACTOR : 1

TOTAL RECOVERABLE PETROLEUM HYDROCARBON		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Petroleum Hydrocarbon	10 mg/Kg	< 10 mg/Kg

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-1
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW12: 10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	1310 mg/KgCaCO3
Analyzed using EPA 310.1 on 28-JUN-1993 by BWB		
Moisture (Oven)	0.01 %	14.0 %
Analyzed using ASTM D2216 on 25-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	280 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-JUN-1993 by MKS		
pH		9.0
Analyzed using EPA 9045 on 25-JUN-1993 by BWB		
Total Solids	0.01 %	86.0 %
Analyzed using EPA 160.3 on 28-JUN-1993 by KOB		

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-2
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW13: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	1350 mg/KgCaCO3
Analyzed using EPA 310.1 on 28-JUN-1993 by BWB		
Moisture (Oven)	0.01 %	16.2 %
Analyzed using ASTM D2216 on 25-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	140 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-JUN-1993 by MKS		
pH		8.8
Analyzed using EPA 9045 on 25-JUN-1993 by BWB		
Total Solids	0.01 %	83.8 %
Analyzed using EPA 160.3 on 28-JUN-1993 by KOB		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-3
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW14: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	490 mg/KgCaCO3
Analyzed using EPA 310.1 on 28-JUN-1993 by BWB		
Moisture (Oven)	0.01 %	19.8 %
Analyzed using ASTM D2216 on 25-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	350 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-JUN-1993 by MKS		
pH		8.9
Analyzed using EPA 9045 on 25-JUN-1993 by BWB		
Total Solids	0.01 %	80.2 %
Analyzed using EPA 160.3 on 28-JUN-1993 by KOB		

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General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-4
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW15: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	1260 mg/KgCaCO3
Analyzed using EPA 310.1 on 28-JUN-1993 by BWB		
Moisture (Oven)	0.01 %	13.4 %
Analyzed using ASTM D2216 on 25-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	252 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-JUN-1993 by MKS		
pH		9.1
Analyzed using EPA 9045 on 25-JUN-1993 by BWB		
Total Solids	0.01 %	86.6 %
Analyzed using EPA 160.3 on 28-JUN-1993 by KOB		

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-5
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW16: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Alkalinity	0.1 mg/KgCaCO3	1360 mg/KgCaCO3
Analyzed using EPA 310.1 on 28-JUN-1993 by BWB		
Moisture (Oven)	0.01 %	14.0 %
Analyzed using ASTM D2216 on 25-JUN-1993 by RJS		
Nitrogen, Total Kjeldahl	10.0 mg/Kg	280 mg/Kg
Dilution Factor : 1 Analyzed using EPA 351.3 on 28-JUN-1993 by MKS		
pH		8.6
Analyzed using EPA 9045 on 30-JUN-1993 by BWB		
Total Solids	0.01 %	86.0 %
Analyzed using EPA 160.3 on 28-JUN-1993 by KOB		

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-6
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : SB7: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 24-JUN-1993

MISCELLANEOUS ANALYSES		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Total Solids	0.01 %	88.4 %
Analyzed using EPA 160.3 on 6-JUL-1993 by CLM		

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-1
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW12: 10-11
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	76.9 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 25-JUN-1993 by CCM
Analyzed using EPA 6010 on 29-JUN-1993 by KJS

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-2
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW13: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 22-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	73.5 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 25-JUN-1993 by CCM
Analyzed using EPA 6010 on 29-JUN-1993 by KJS

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Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-3
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW14: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	90.9 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 25-JUN-1993 by CCM
Analyzed using EPA 6010 on 29-JUN-1993 by KJS

NDRC Laboratories, Inc. Martin Jeffus VL
Martin Jeffus
General Manager

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-4
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW15: 11-12
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	118 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 25-JUN-1993 by CCM
Analyzed using EPA 6010 on 29-JUN-1993 by KJS

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BEAUMONT DALLAS HOUSTON

DATE RECEIVED : 24-JUN-1993

REPORT NUMBER : D93-7276-5
REPORT DATE : 8-JUL-1993

SAMPLE SUBMITTED BY : Engineering-Science Inc.
ADDRESS : 7800 Shoal Creek Blvd, Suite 222W
: Austin, TX 78757
ATTENTION : Mr. Brian Vanderglas

SAMPLE MATRIX : Soil
ID MARKS : VW16: 9-10
PROJECT : AU380.01 Carswell AFB Biovent
DATE SAMPLED : 23-JUN-1993

TOTAL METALS		
TEST REQUESTED	DETECTION LIMIT	RESULTS
Phosphorus	1.0 mg/Kg	105 mg/Kg

Dilution Factor : 1
Prepared using EPA 3051 on 25-JUN-1993 by CCM
Analyzed using EPA 6010 on 29-JUN-1993 by KJS

NDRC Laboratories, Inc. Martin Jeffus VL

Martin Jeffus
General Manager

Appendix D

Lithologic Logs

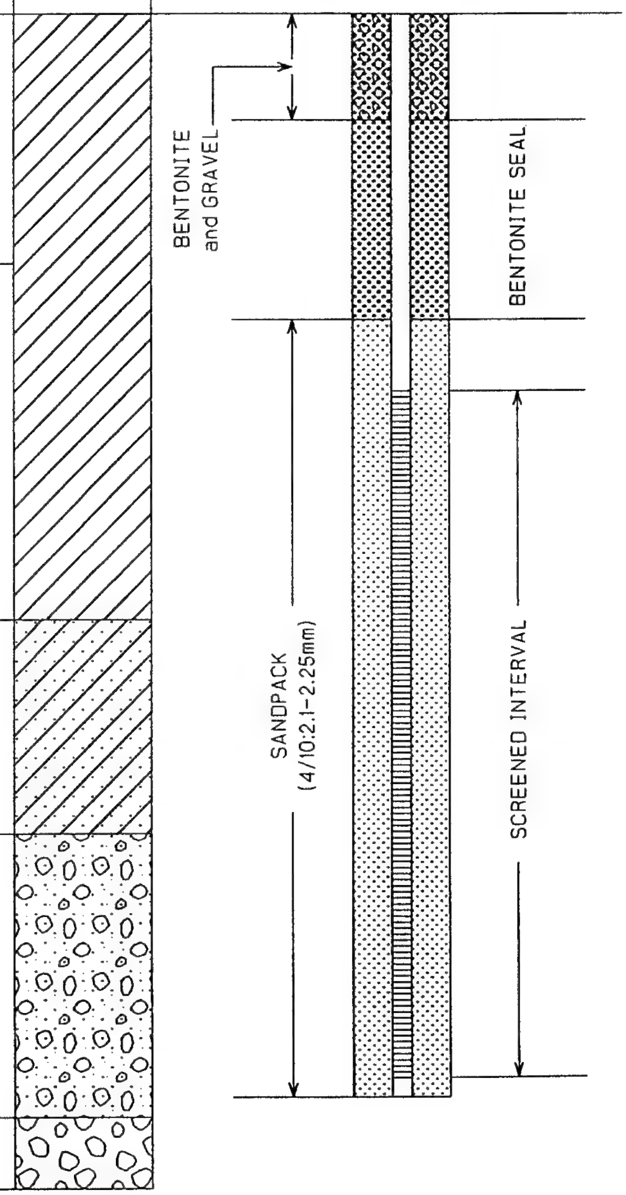
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 1 (VW1)
ROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 16.5
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 25 MAY 1993
RILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.32" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HOSP)	LITHOLOGIC DESCRIPTION
0	0.5		30	CLAY, dark brownish, black with gravel, moist, slight odors observed. OVA scan = 30 ppm.
			(>5000)	CLAY, olive gray, some sand, few gravel, damp, odors observed.
5	5.0	X		
			(>5000)	SANDY CLAY, light olive gray (mottled), few carbonate nodules, moist. strong odors.
10	3.0	X	(>5000)	
				Olive gray medium to coarse SAND with small GRAVEL, saturated, strong odors.
15				GRAVEL
				Total Depth = 16.5 ft.
20				

GRAPHIC LOG

WELL DIAGRAM



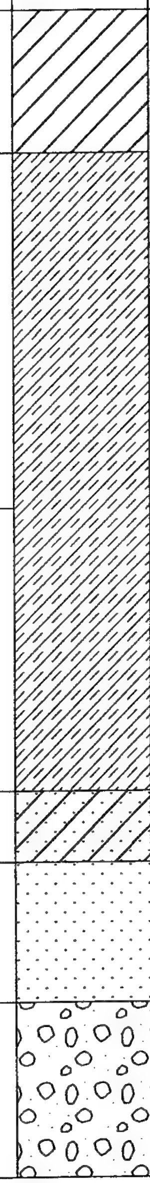
FILE: VW1

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

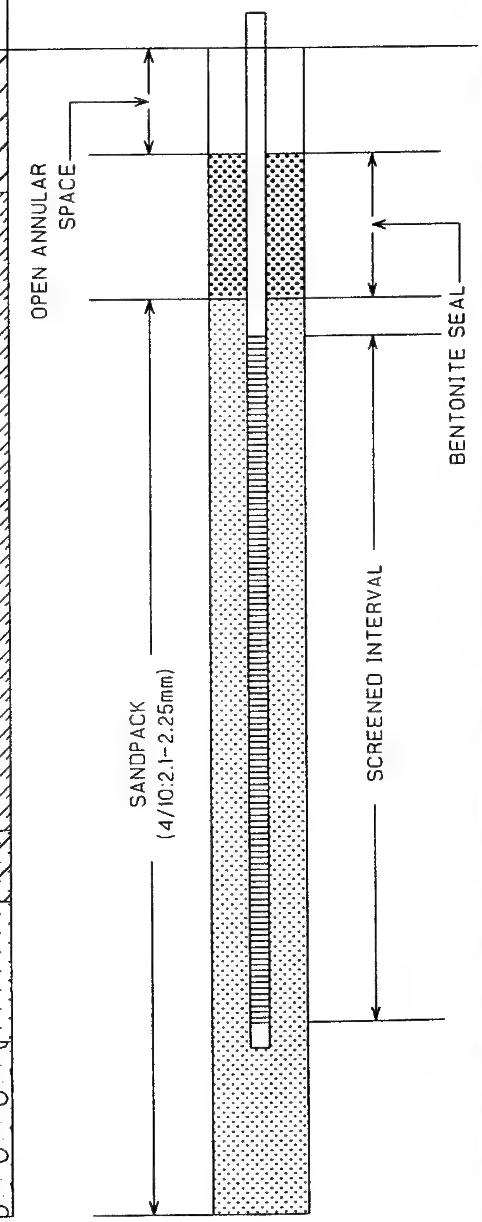
CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 2 (VW2)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 16.5
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 15 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	3.5		150	Dark, olive gray to black CLAY with gravel, damp, hydrocarbon odors observed, OVA scan = 150 ppm.
			(>5000)	Dark olive gray SILTY CLAY, plastic, damp, fuel odors observed, OVA scan = 100 − 300 ppm.
5	3.8		(2000) 350	Olive gray SILTY CLAY with some medium gravel and $CaCO_3$ nodules, damp. Slight mottling and odors observed increasing sand content with depth.
10	3.8	X	3000	Olive gray CLAYEY SAND, moist, odors.
			1300	Olive gray fine to medium SAND, trace clay, wet. OVA scan = 1300 ppm.
15	2.5			Light yellowish brown SANDY GRAVEL with medium to fine pebbles and coarse sand, saturated, light hydrocarbon odor.
20				*Total Depth = 16.5 ft.*

GRAPHIC LOG



WELL DIAGRAM



FILE: VW2

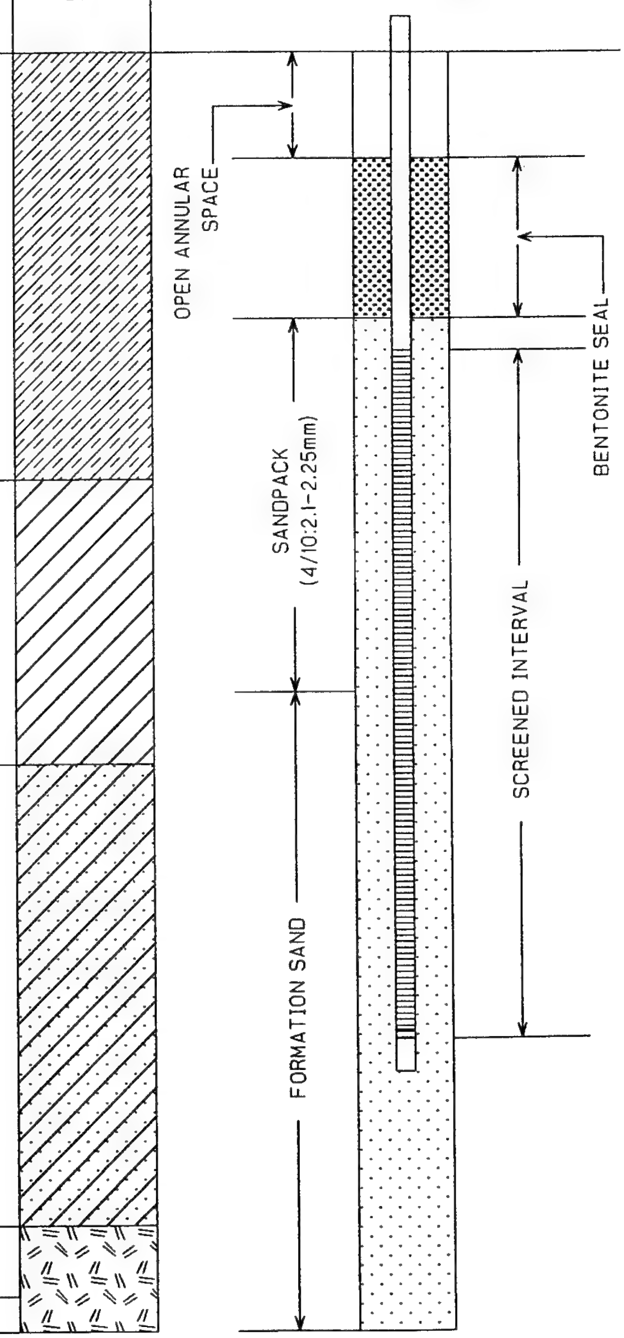
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 3 (VW3)
ROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 16 JUNE 1993
RILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	1.3			Dark olive gray SILTY CLAY with some small to medium gravel and nodules, damp, no odors.
	1.8		(80)	
			320	
5	5.0	X	(1400)	Dark olive gray CLAY, many small carbonate nodules, very firm, damp.
			350	
			500	
10	2.0	X	600	Light olive gray CLAYEY fine SAND, wet.
15				Weathered shale material encountered.
				Rock encountered (no sample collected).
				Total Depth = 18.0 ft.
20				

GRAPHIC LOG

WELL DIAGRAM



FILE: VW3

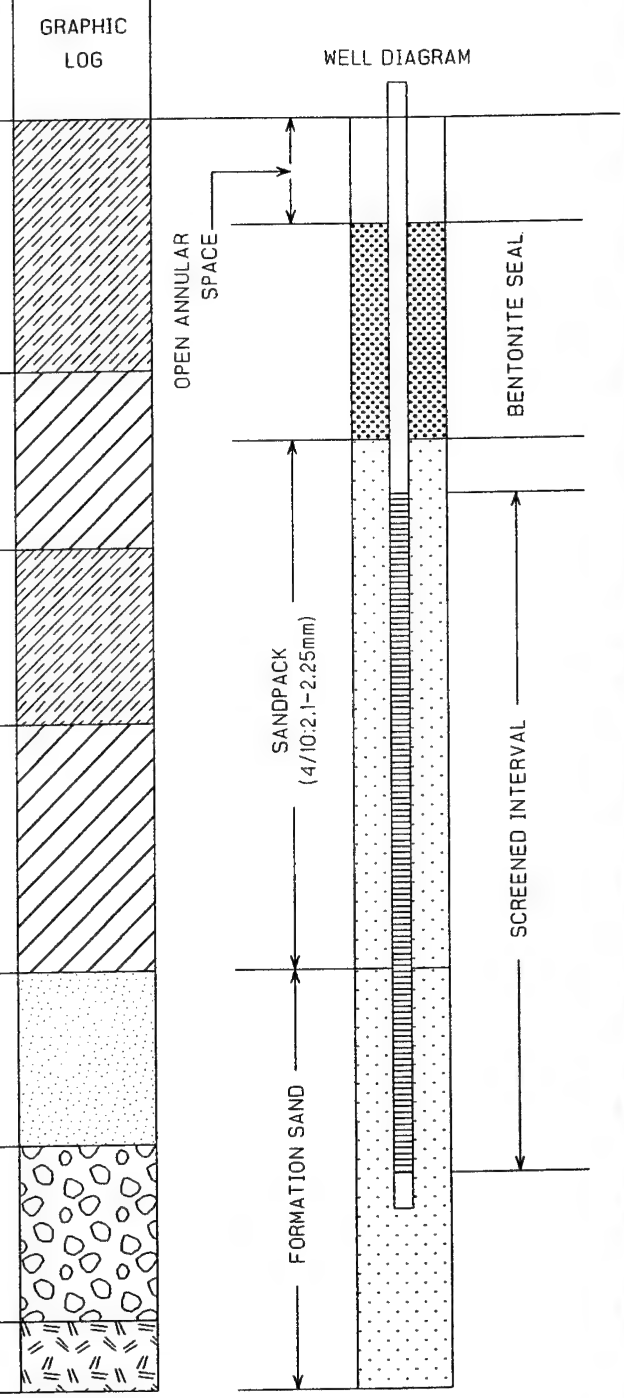
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 4 (VW4)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 16 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
1.5			Dark olive gray SILTY CLAY, some gravel, damp, slightly plastic, slight hydrocarbon odor.
1.9			Dark olive gray CLAY, very plastic, damp, very firm, slight odor.
5.0			Olive gray SILTY CLAY, slight damp, few carbonate nodules, firm, slight odor.
5.0			Olive gray CLAY, very plastic with a saturated clayey sand seam. slight odor.
			Olive gray fine SAND, trace clay, wet, slight hydrocarbon odor.
			GRAVEL
			ROCK

Depth scale (ft): 0, 5, 10, 15, 20

Total Depth = 18.0 ft.



FILE: VW4

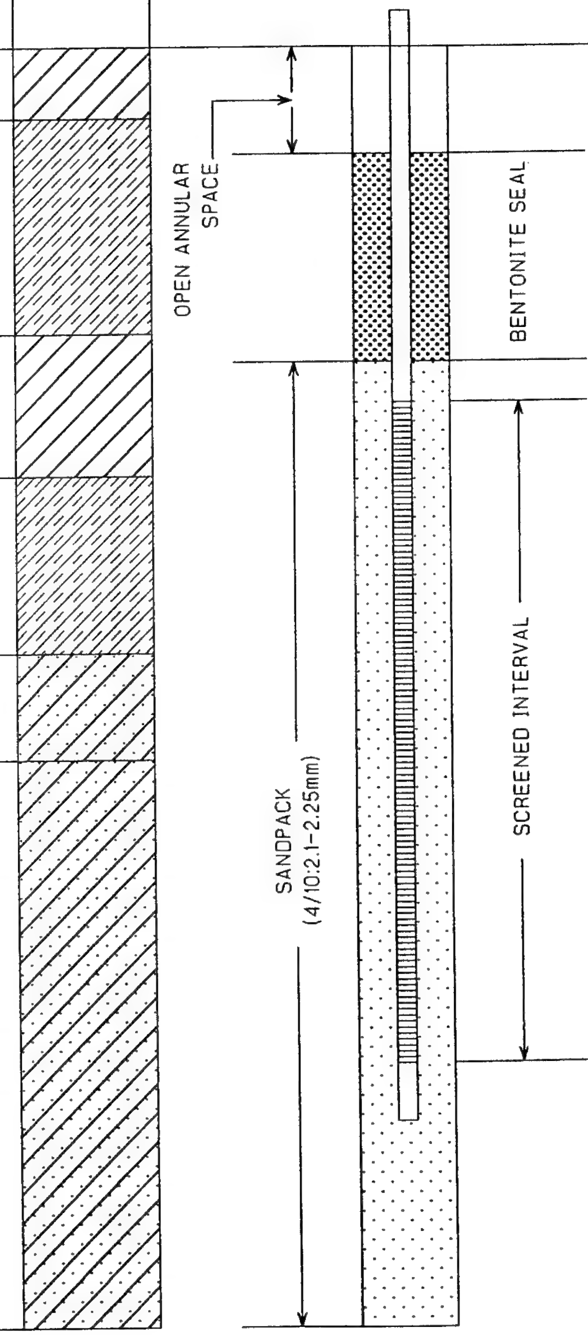
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 5 (VW5)
OJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 16 JUNE 1993
ILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
1.5			Dark olive gray to black CLAY, very firm, very plastic.
1.8			Dark olive gray SILTY CLAY, slightly firm, damp, hydrocarbon odor observed.
5.0			Dark olive gray to black CLAY, few small to medium gravel, very plastic, damp, slight odor, very firm.
	X		Olive gray SILTY CLAY, firm, damp, increasing odors and moisture content with depth.
			Olive gray fine SANDY CLAY, moist, odors.
3.2	X		Olive gray CLAYEY fine SAND, wet at 12.5' bgs.

Total Depth = 18.0 ft.

GRAPHIC LOG / WELL DIAGRAM



Depth scale: 5, 10, 15, 20

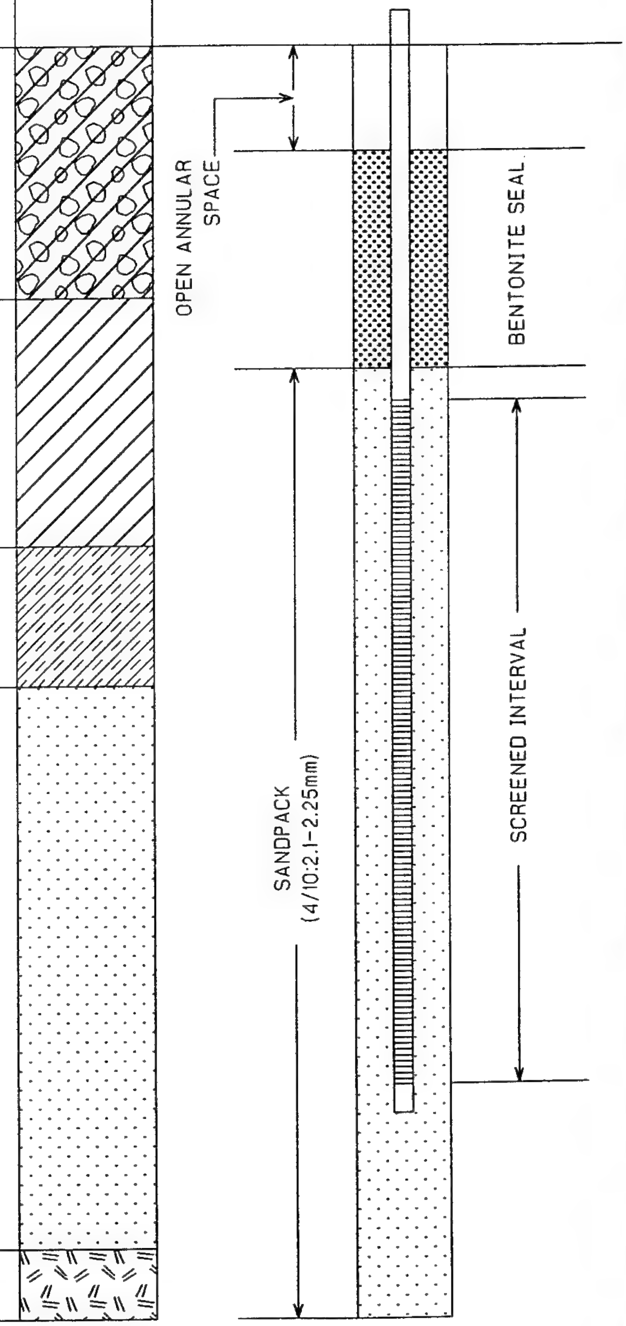
FILE: VW5

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 6 (VW6)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 17 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

DEPTH	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	0.0			No recovery.
	0.0			
			50	Dark olive gray to black CLAY, very plastic, some medium to large gravel, slight odor.
5	5.0		60 (3400)	
			500	Olive gray SILTY CLAY, medium gravel, odors.
10	2.5	⧗	>500	Light olive gray to gray clayey SAND to mostly sand at 9.5' bgs., strong odors
15				
				ROCK
				Total Depth = 18.0 ft.
20				

GRAPHIC LOG | WELL DIAGRAM



FILE: VW6

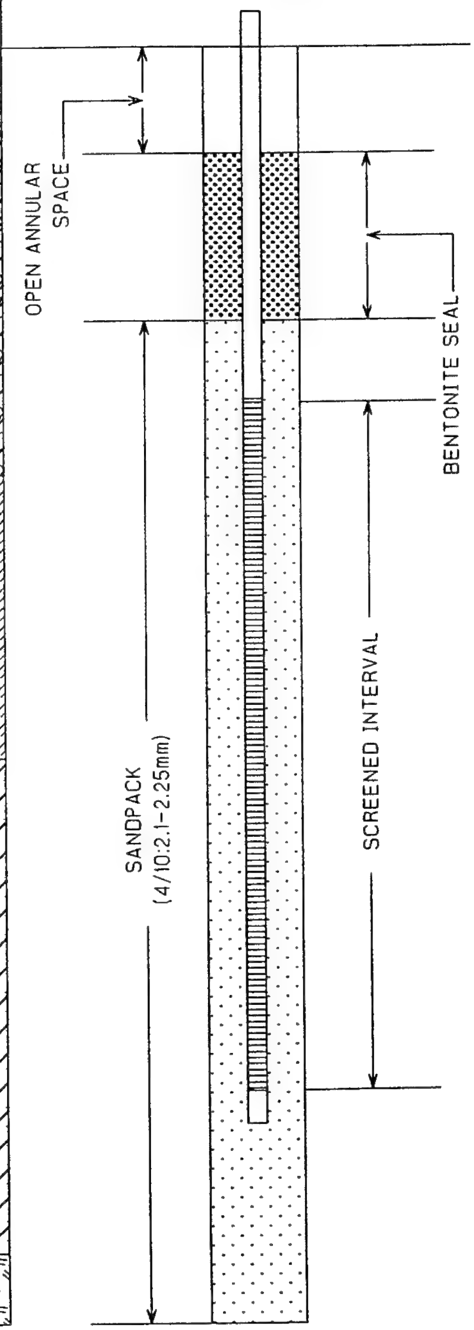
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 7 (VW7)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 17 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION	GRAPHIC LOG
0.0			No recovery.	
0.0				
		50	Black CLAY with medium GRAVEL, damp.	
8.5		60		
		150	Olive gray SILTY CLAY, with some gravel, damp, mottling from 8.5' to 10'bgs. Strong hydrocarbon odors observed.	
		(2900)		
2.5	X	2500		
		>5000	Olive gray CLAYEY SAND, moist, odors observed.	
			ROCK	

Total Depth = 18.0 ft.

WELL DIAGRAM



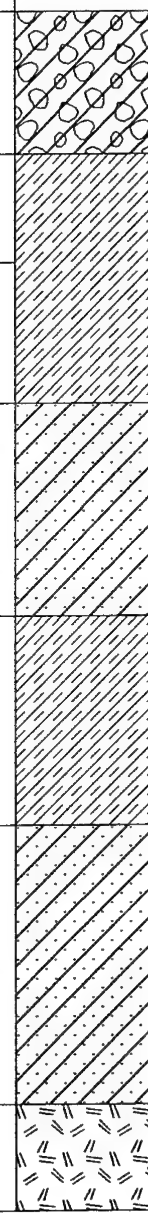
FILE: VW7

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

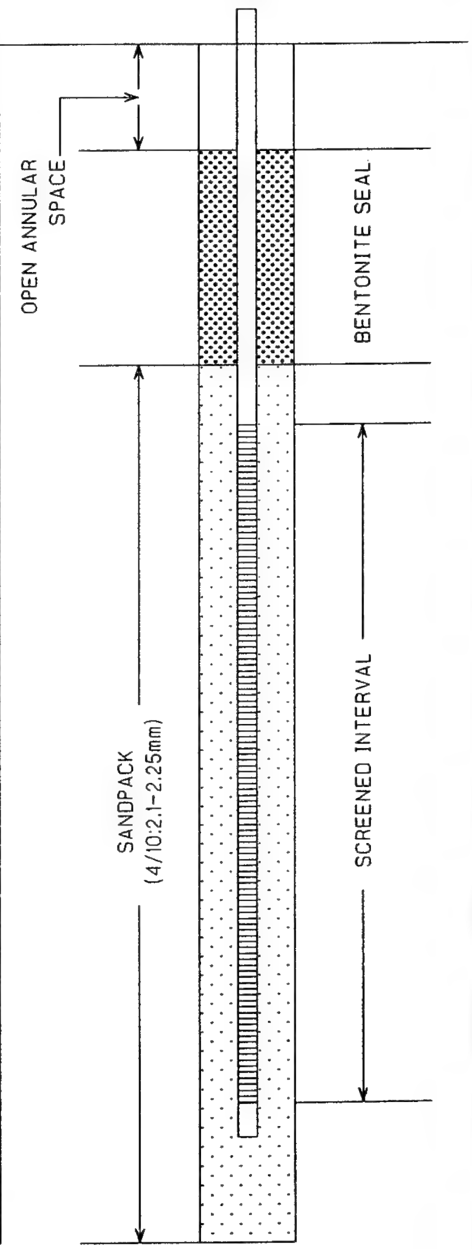
CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 8 (VW8)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 17.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 17 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	0.4			CLAY and GRAVEL fill material.
	1.0		30 (1500)	Olive gray SILTY CLAY, slight odors detected. Yellowish-brown SILTY CLAY with many medium gravel.
5	3.3			Olive gray fine SANDY CLAY, slightly damp, few pebbles.
			130 (2900)	Olive gray SILTY CLAY, damp, plastic, strong odors.
10	5.0	X	1000 1100 1100	
			2400	Olive gray fine CLAYEY SAND, moist, firm, strong hydrocarbon odors.
15				ROCK
				Total Depth = 17.0 ft.
20				

GRAPHIC LOG



WELL DIAGRAM



FILE: VW8

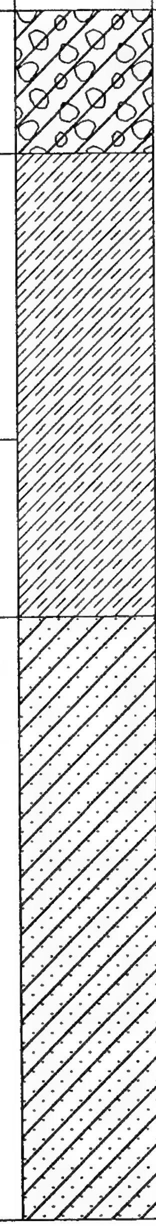
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 9 (VW9)
ROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 17.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 18 JUNE 1993
RILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

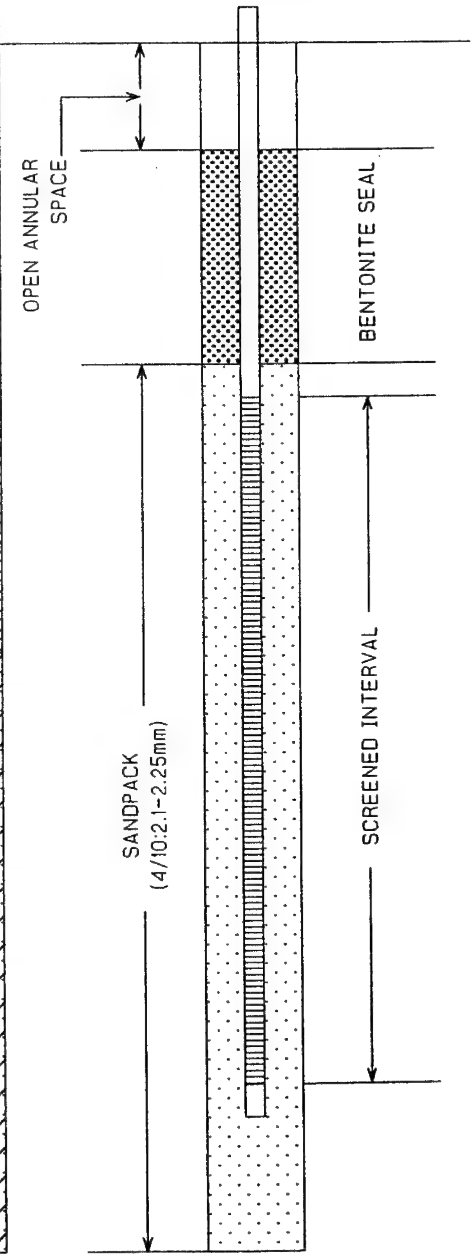
INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
1.7		11	Black CLAY with GRAVEL, no odors detected.
2.0		(35) 14	Dark olive gray SILTY CLAY with small to medium gravel, slightly damp, no odors.
5.0		55 (380)	Olive gray SILTY CLAY, to clay loam, no odors.
3.5	X	1100 4300	Olive gray fine SANDY CLAY, damp to moist, strong hydrocarbon odors.

Total Depth = 17.0 ft.

GRAPHIC LOG



WELL DIAGRAM



FILE: VW9

ENGINEERING-SCIENCE, INC.

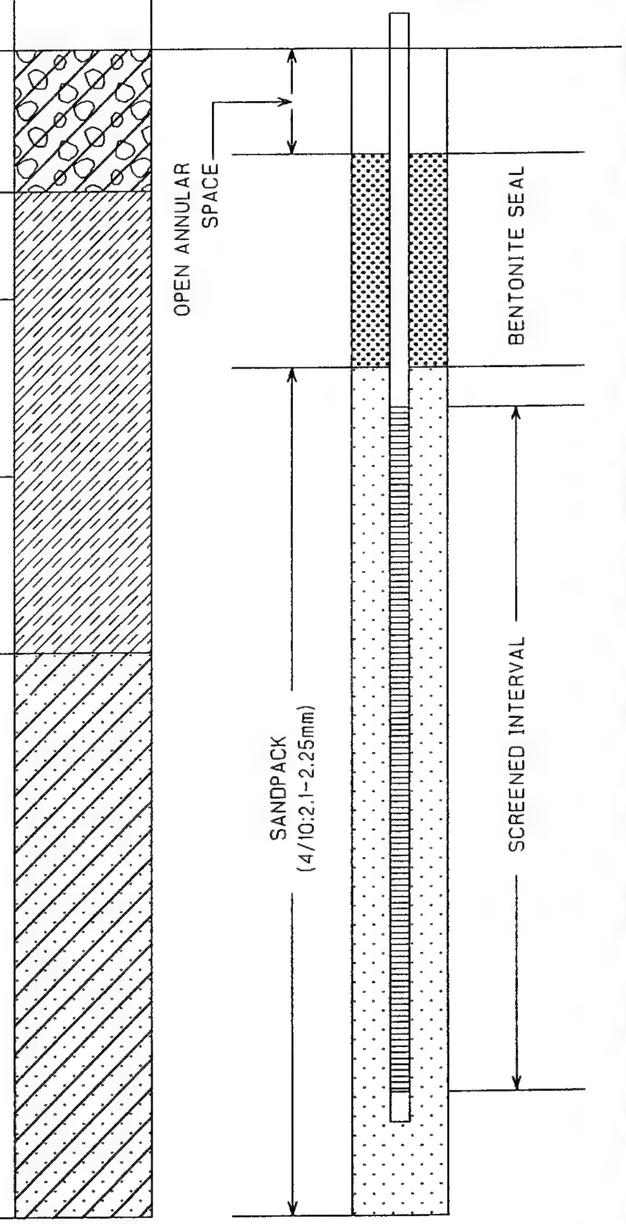
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 10 (VW10)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 16.5
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 22 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	0.5			Black CLAY, some GRAVEL, very plastic, damp to moist.
	1.8			Dark olive gray SILTY CLAY, few caliche nodules, firm, slight odor.
				Light reddish brown SILTY CLAY, small caliche nodules and trace, firm, damp, wet gravel seam at 5.5'bgs.
5	5.0			Olive gray SILTY CLAY, damp, very firm, slight odors, increasing with depth.
10	5.0	X		Olive gray fine SANDY CLAY, firm, very plastic and damp. Soft zone at 10.5 – 11'bgs.
15				
				Total Depth = 16.5 ft.
20				

GRAPHIC LOG

WELL DIAGRAM



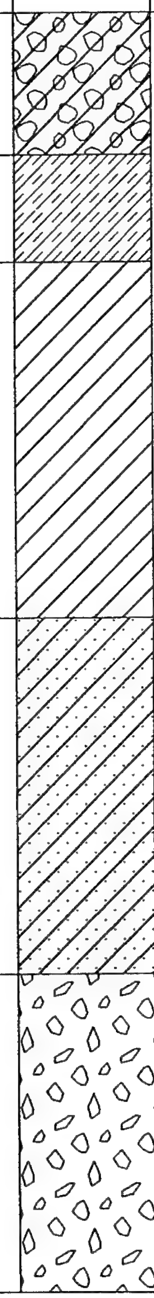
FILE: VW10

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

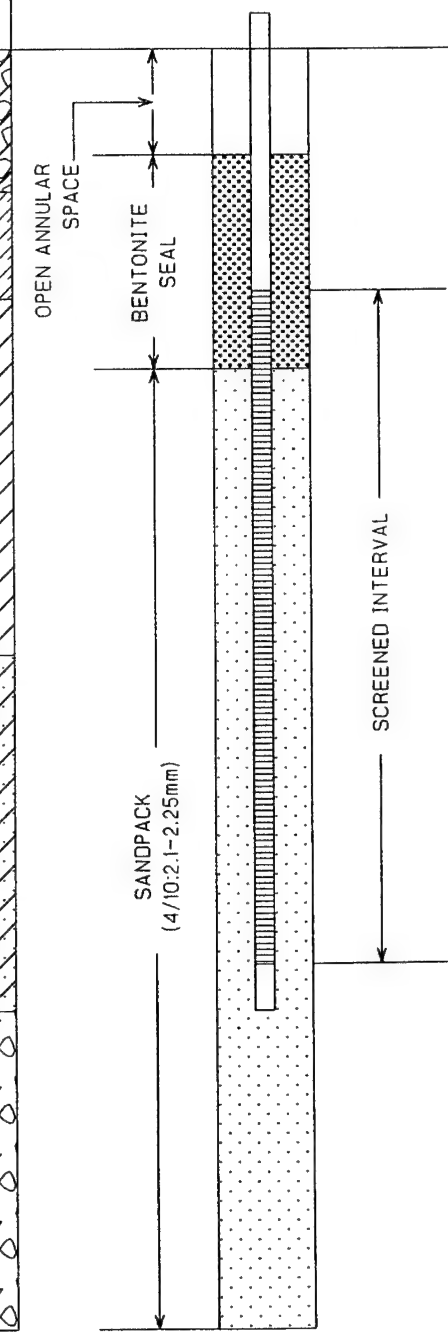
CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 11 (VW11)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 24 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION (Soil boring 2 lithology)
0.5			CLAY with GRAVEL.
1.8		350 (1800)	Olive gray SILTY CLAY, firm, damp, no odors.
3.8		30 (500)	Dark olive gray CLAY with many gravel, plastic.
2.0		>5000	Olive gray fine SANDY CLAY, increasing sand content with depth, strong fuel odors, moist.
			GRAVEL.
			Total Depth = 18.0 ft.

GRAPHIC LOG



WELL DIAGRAM



FILE: VW11

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

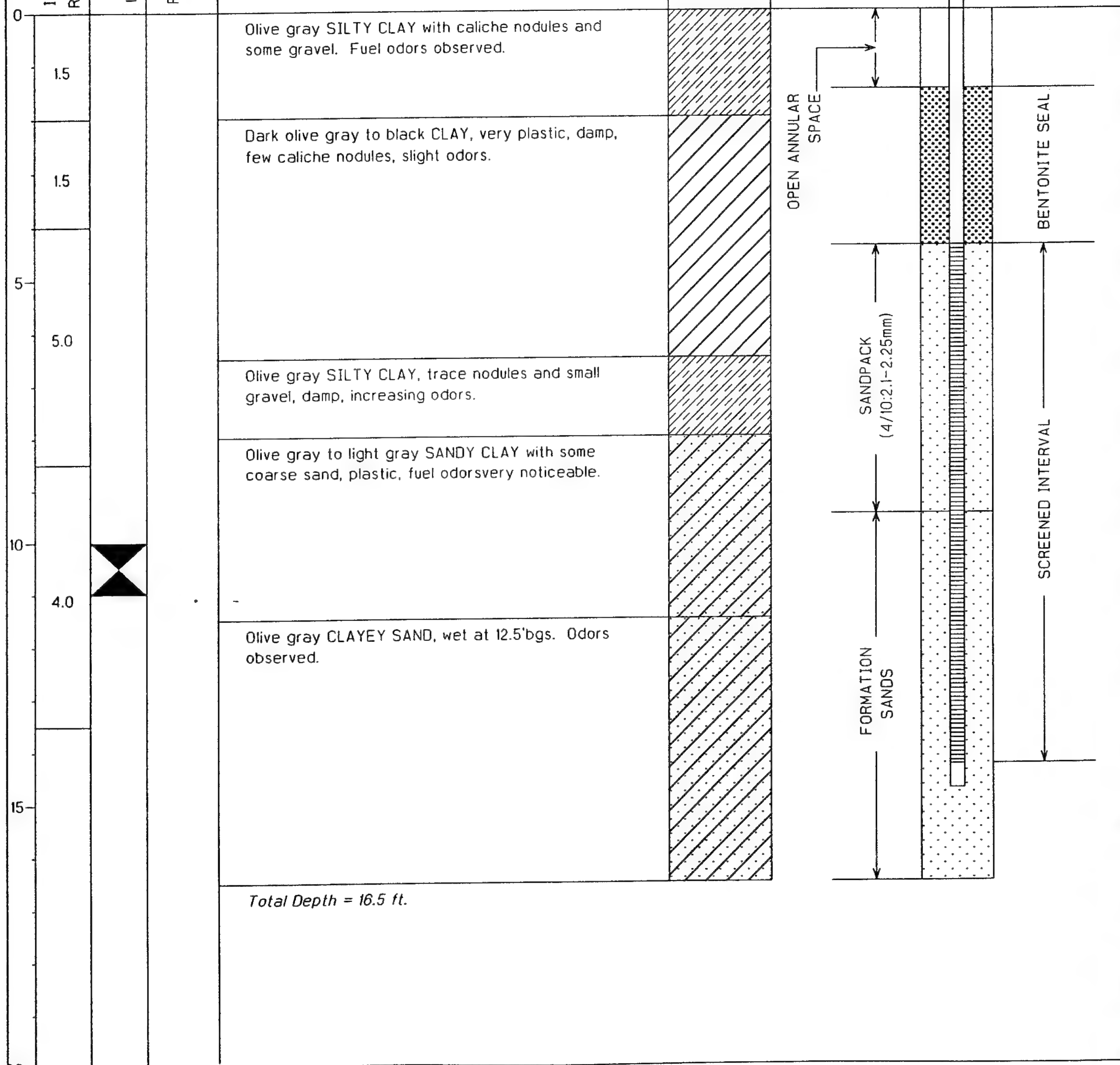
CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 12 (VW12)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 16.5
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 22 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
1.5			Olive gray SILTY CLAY with caliche nodules and some gravel. Fuel odors observed.
1.5			Dark olive gray to black CLAY, very plastic, damp, few caliche nodules, slight odors.
5.0			Olive gray SILTY CLAY, trace nodules and small gravel, damp, increasing odors.
4.0			Olive gray to light gray SANDY CLAY with some coarse sand, plastic, fuel odorsvery noticeable.
			Olive gray CLAYEY SAND, wet at 12.5'bgs. Odors observed.

Total Depth = 16.5 ft.

GRAPHIC LOG

WELL DIAGRAM



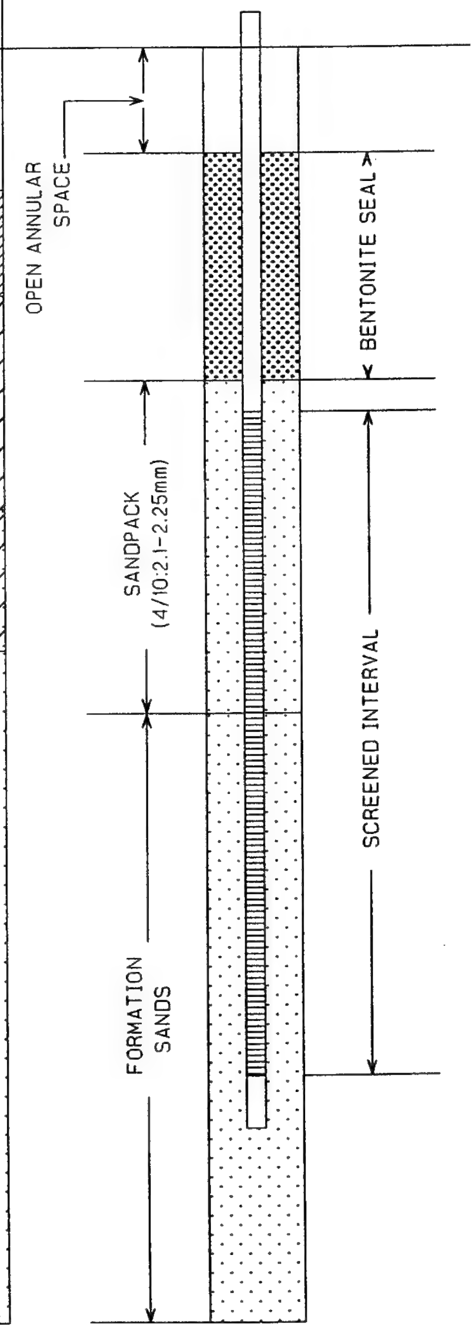
FILE: VW12

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 13 (VW13)
ROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 23 JUNE 1993
RILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

DEPTH	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION	GRAPHIC LOG
0	1.5			No recovery.	
	1.5			Olive gray SILTY CLAY, slight odors.	
5	5.0			Black CLAY, few gravel, plastic, damp, very firm, no odors.	
				Olive gray SANDY CLAY, plastic, damp, firm, odors noticeable.	
10	4.0			Olive gray fine SAND, trace clay, moist, strong hydrocarbon odors. Wet at 12'bgs.	
15					
0				*Total Depth = 18 ft.*	

WELL DIAGRAM



FILE: VW13

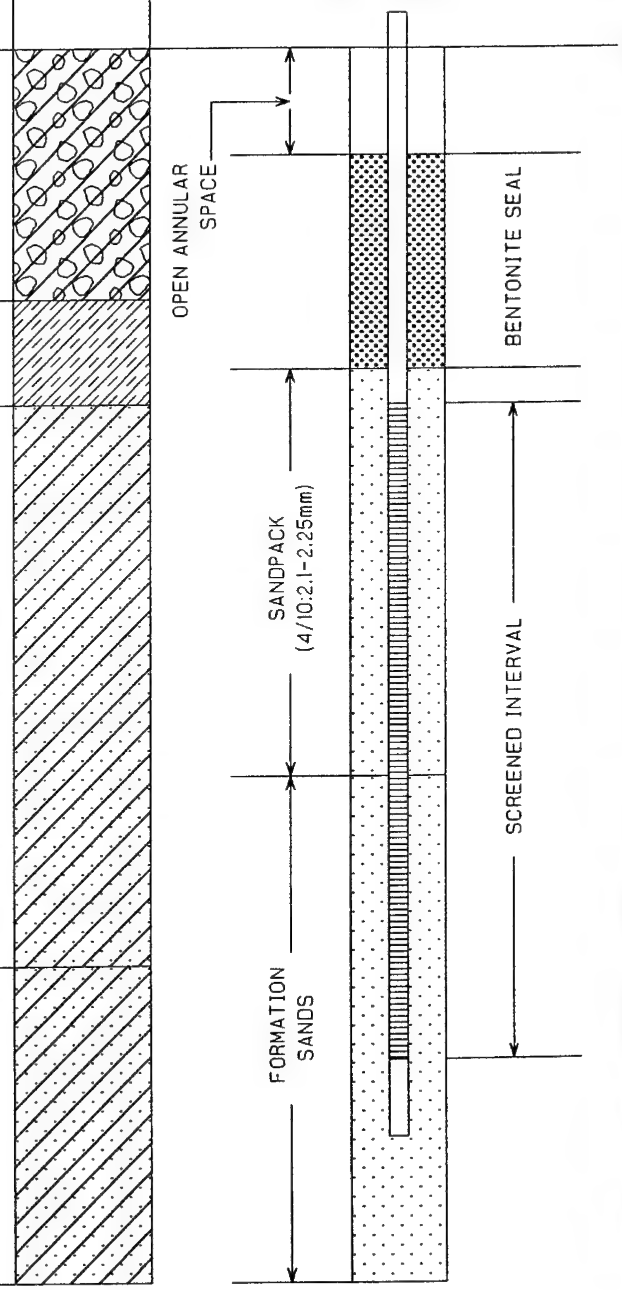
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 14 (VW14)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 17.5
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 23 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	0.0			No recovery due to gravel in split spoons.
	0.0			
			0	Dark brown SILTY CLAY, some small to medium gravel, firm, damp, no odors.
5	3.5		1200	Olive gray fine SANDY CLAY, plastic, damp, firm to very firm, odors observed.
			3500	
			1200	
10	5.0			
			2000 (>5000)	
			1500	Olive gray and mottling CLAYEY fine SAND, odors.
15				
20				*Total Depth = 17.5 ft.*

GRAPHIC LOG

WELL DIAGRAM

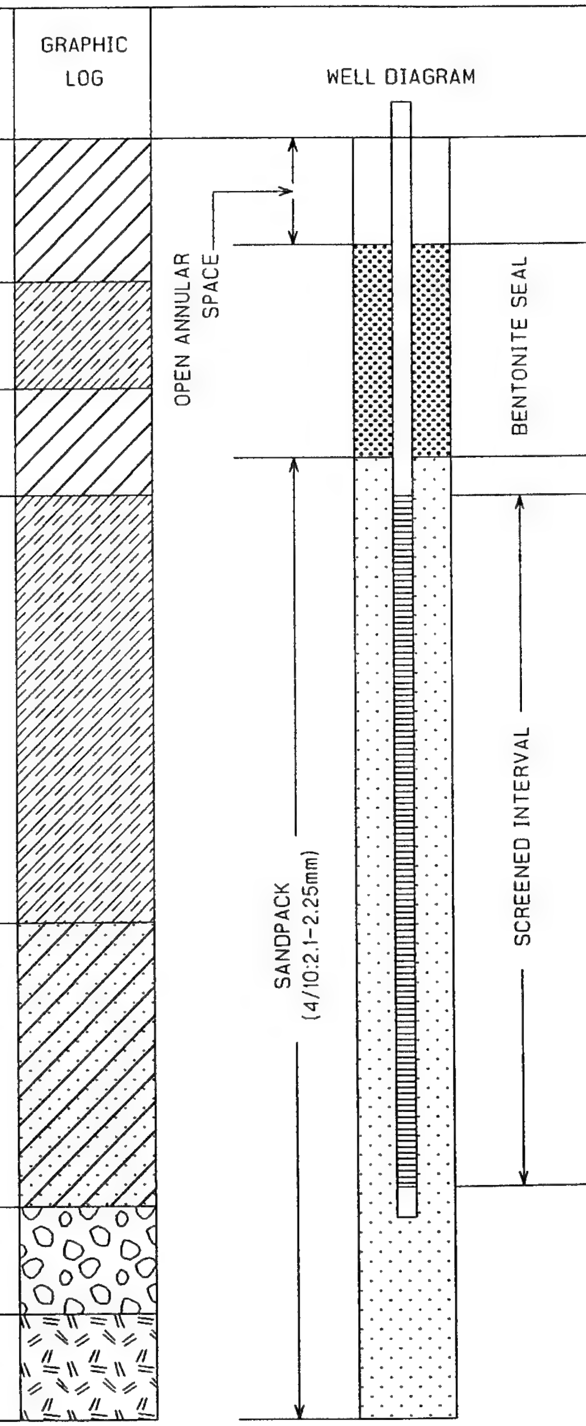


FILE: VW14

ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 15 (VW15)
ROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 23 JUNE 1993
RILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

Depth	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	1.0			Black CLAY, very plastic, damp, some gravel, no odors.
	1.0			Olive gray SILTY CLAY, damp, slight odor.
				Black CLAY, plastic, few gravel, very firm.
5	5.0			Olive gray SILTY CLAY with small caliche nodules. Increasing sand content below 8.5', damp, very firm, odors.
10	5.0			Olive gray CLAYEY SAND, moist, wet at 12', odors observed.
5				GRAVEL.
				ROCK.
0				*Total Depth = 18 ft.*



FILE: VW15

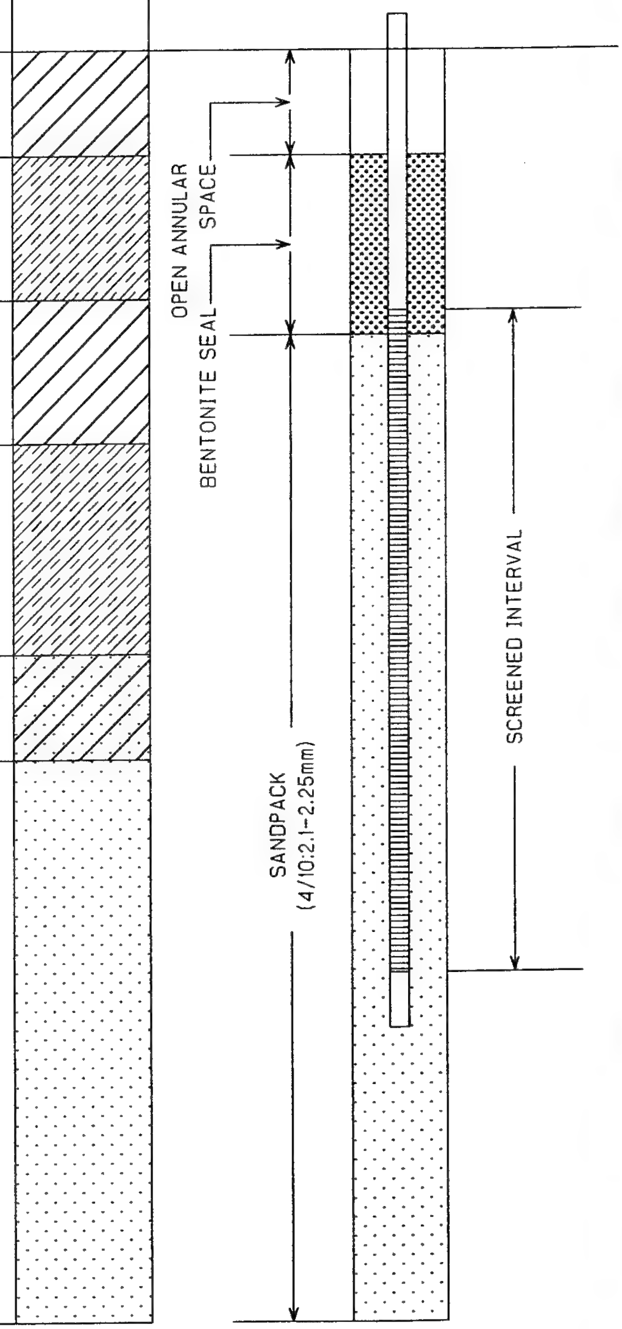
ENGINEERING-SCIENCE, INC.
VENT WELL COMPLETION

CLIENT: CARSWELL AFB	WELL NUMBER: VENT WELL 16 (VW16)
PROJECT: ST14 BIOVENT PILOT STUDY	TOTAL DEPTH: 18.0
DRILLING FIRM: PROFILE FIELD SERVICES	WELL COMPLETION: 23 JUNE 1993
DRILLING RIG: CME75 HSA	BOREHOLE DIAMETER: 9 in.
LOGGED BY: BRIAN VANDERGLAS	CASING/SCREEN: 4 in. SCHED. 40 PVC, 0.36" SLOT SIZE

DEPTH	INTERVAL RECOVERY	SAMPLE LOCATION	FID SCAN (HDSP)	LITHOLOGIC DESCRIPTION
0	1.8			Black CLAY, very plastic, firm, damp, no odors.
	1.5			Olive gray SILTY CLAY, firm, damp, slight odors.
				Dark olive gray CLAY, few nodules, very plastic, damp, slight odors.
5	5.0			Olive gray SILTY CLAY with common small caliche nodules, very firm, damp, slight odors.
		⧗		Olive gray fine CLAYEY SAND, strong odors.
10	2.0			Olive gray fine SAND, trace clay, wet at 12.5'bgs. Strong odors.
15				
				Total Depth = 18 ft.
20				

GRAPHIC LOG

WELL DIAGRAM



FILE: VW16

SHEET OF

DRILL LOG

CLIENT

WELL OR BORING NUMBER MPA

PROJECT Bioventing

LOCATION POL Tank Farm, Fuel loading

DRILLING FIRM Profile

G.L. ELEVATION

LOGGER BRV

DRILLING RIG CME 75 HSA

RIG OPERATOR Tom Placek.

BEGINNING 5/25/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 5/25/93

GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	100% recovery	Olive black clay, light odors Few clay films. dry to damp	OVA scan = <50 ppm
	2-4'	100% recovery	olive gray clay, light odors some small nodules.	scan 50-200 ppm
5	3½-8½'	100% recovery	Black highly plastic clay large gravel (Fill) from 3½-5' damp.	OVA scan 50-250 ppm
			Light olive gray, dry to damp clay few small nodules. slight mottling	5000 ppm scan at 9½'
10	8½-13½'		light gray Fine sandy clay, moist odors	~~500-1000~~ ppm 500-1000
			light olive gray to olive at 13½'. ~~clay~~ sandy clay and clay intermixed damp	4000 @ 13'
			clayey sand, light olive gray at 13'.	
15				
			TD 13.5'.	
20				
25				

SHEET OF

PAGE

DRILL LOG

CLIENT Carswell AFB

WELL OR BORING NUMBER MPB

PROJECT Biovent Test System

LOCATION POL Tank Farm, Fuel loading area

DRILLING FIRM Profile Field services

G.L. ELEVATION

LOGGER BRV

DRILLING RIG CME 75 HSA

RIG OPERATOR Tom Placek

BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION

GROUNDWATER LEVEL FIRST ENCOUNTERED 11.5' AND FINAL

DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	No	Fill material, highly plastic black clay with large gravel Fill.	No recovery pushed shelby tube 1-3'.
			olive black, highly plastic clay w/ med to large gravel (fill), damp (oily)	odors,
5	3½-8½'		olive gray ~~sa~~ clay with little fine sand, few nodules (small) damp, plastic.	increasing odors Headspace @ 7' = >5000 ppm
10	8½-11½'		light olive gray to olive sandy clay (fine sand) moist to wet at 11½'. plastic soils	Headspace @ 10' = >5000 ppm
			TD ~~11.5'~~ BRV 11.2' TD tagged	
15				
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SHEET OF PAGE

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER MPC
PROJECT Bioventing system
LOCATION Fuel loading area, POL
DRILLING FIRM Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	2' recovery	Brownish black clay with few small to medium gravel. damp	odors OVA Scan = 500 ppm
	2-4'	1½' recovery	olive gray silty clay, few small nodules, dry to damp. ~~wea~~ moderate structure	odors OVA Scan = 2000 ppm
5	3½-8½	4.2' recovery	olive black & ~~dark~~ olive gray clay very firm & plastic damp. heavy odors. medium to large gravel from 3½-5'.	OVA scan = 2000 ppm
	8½-~~11½~~ 12'	4' recovery	light olive gray silty clay, many small nodules	~~OVA~~
			light olive gray fine sandy clay/ somewhat mottled plasticity is high strong odors, ~~moist~~ damp to moist.	OVA = 3000 ppm
10			light olive gray clayey fine sand, moist	heavy odors
			TD = ~~11.5~~ 12.2'	
15				
20				
25				

SHEET OF

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER MP BG-2
PROJECT ST14 Bioventing
LOCATION POL Farm, near warehouse
DRILLING FIRM BAII Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 6/15/93 AND END OF DRILLING AND CONSTRUCTION OPERATION 6/15/93
GROUNDWATER LEVEL FIRST ENCOUNTERED ______ AND FINAL ______
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2	6" recovery	small gravel, loam, sand	
	2-4'	6" recovery	silty clay with some small to medium, dark brown	OVA scan = 0 ppm
5	3½-8½	3.25' recovery	dark olive gray silty clay w/ small to med. gravel. very firm damp.	headspace @ 6' = 0.5 ppm
			light olive gray coars to fine sandy clay. damp.	OVA scan = 0 ppm
10	8½-12	4.0' recovery	light olive gray fine sandy clay, highly plastic and moist. wet @ 12'. No odors.	OVA scan = 0 ppm 10 sample MPBG-2-2 collected 10-10.5'. headspace @ 10' = 0.0 ppm
			12' TD.	
15				15
20				20
25				25

SHEET OF PAGE

DRILL LOG (SB1)

CLIENT Carswell AFB
WELL OR BORING NUMBER MPBG1
PROJECT Bioventing Test system
LOCATION Fuel loading area (P02)
DRILLING FIRM Prosser Field services
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME75 HSA
RIG OPERATOR Tom Placek
BEGINNING 5/26/93 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	1½' recovery	light brown silty clay with small to med gravel & nodules. dry to damp. no odors	
	2-4		olive black clay, few small nodules. damp. hydrocarbon odors.	Headspace @3' = 5000 ppm scan = 200 ppm
5	3½-8½	3' recovery	light brown & Black highly plastic clay with small to medium gravel. dry to damp	
			light olive gray fine sandy clay with few small nodules and gravel. damp.	Headspace at 7' = 400-300 ppm scan odors.
10	8½-12½'	3½' recovery	Same as above	
			light gray clayey sand (fine) moist to wet at bottom. Strong odors	sample for BTEX TPH @ 10-11'. OVA scan = 4500 ppm
			H_2O at 12'.	
15				
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SHEET OF — PAGE

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER SB2
PROJECT Bioventing ST14
LOCATION POL fuel loading area
DRILLING FIRM Profile
G.L. ELEVATION —
LOGGER BRV
DRILLING RIG CME75 HSA
RIG OPERATOR Tom Placek
BEGINNING 18 June 93 AND END OF DRILLING AND CONSTRUCTION OPERATION 18 June 93
GROUNDWATER LEVEL FIRST ENCOUNTERED ______ AND FINAL ______
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2	.5' recovery	Filled with gravel	Splitspoon
	0-3½	1.8' recovery	Olive gray silty clay damp, firm, no odor	Splitspoon OVA Scan = 350 ppm Headspace @ 3' = 1800 ppm
5	3½-8½	3.8' recovery	dark olive gray clay with significant amount of gravel, plastic..	OVA scan = 30-20 ppm Headspace @ 6' = 500 ppm sample SB2 collected from 7-8' bgs for BTEX & TPH
10	~~8½~~ 8½ - ~~13½~~ 13½	2.0' recovery	Olive gray fine sandy clay changing to clayey sand, damp, strong hydrocarbon odors, moist	OVA scan > 5000 ppm. Sample SB2:10-11 collected from 10-11' for BTEX & TPH analysis
			Total depth = 13.5'.	
15				
20				
25				

SHEET OF

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER SB3
PROJECT Bioventing ST14
LOCATION POL tank farm, fuel loading area.
DRILLING FIRM Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 21 June 93 AND END OF DRILLING AND CONSTRUCTION OPERATION 21 June 93
GROUNDWATER LEVEL FIRST ENCOUNTERED 10.5 AND FINAL
DATE: (6/21/93) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
				Splitspoons to 4'
	0-2			No recovery
	0-2			No recovery
5	3½-8½	5' recovery	dark brown clay, very firm, damp, some medium gravel, no odors.	OVA Scan 3½-6½ = 0ppm ~~Feel~~ OVA Scan 6½-8½ = 550ppm Headspace @ 8' = 550ppm
			olive gray clay, some caliche nodules, slight odor, very firm and damp.	
			Same as above	
10	8½-13½	2' recovery	Olive gray fine clayey sand turning to fine sand. Saturated at 10.5' bgs.	~~SB3~~ Sample SB3 ~~collected~~ SB3: 9-10 collected from 9-10 for TPH & BTEX analysis
			Total depth 13.5' bgs	
15				
20				
25				

SHEET OF

DRILL LOG

CLIENT Carswell ~~Bioventing~~ AFB WELL OR BORING NUMBER SB4
PROJECT Bioventing at ST14 LOCATION POL tankfarm, fuel loading area
DRILLING FIRM Profile G.L. ELEVATION ______ LOGGER BRV
DRILLING RIG CME 75 HSA RIG OPERATOR Tom Pleek
BEGINNING 21 June 93 AND END OF DRILLING AND CONSTRUCTION OPERATION 21 June 93
GROUNDWATER LEVEL FIRST ENCOUNTERED ______ AND FINAL ______
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	6" recovery	loamy clay, light reddish brown gravel.	
	2-4	0.3' recovery	Black very plastic clay.	
5	3½-8½	Full recovery	dark olive gray ~~to~~ black clay, plastic with many small to medium gravel. no odors, OVA = 0ppm	OVA scan = 2-8ppm
			olive gray clay, very firm & damp. many small caliche nodules, no odors	Sample SB4:7-8 collected from 7-8' bgs for BTEX + TPH analyses
10	8½-13½	2.5' recovery	Olive gray fine clay sand, moist some mottling. no odors, OVA scan = 0ppm	headspace at 9½' = 3ppm
			Fine sand, trace clay, wet @ 11' no odors, OVA = 0ppm.	sample SB4:10-11 collected from 10-11' bgs for TPH & BTEX
15			TD = 13.5' bgs.	Duplicate sample SB4:DUP also collected from 10-11' bgs.
20				
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SHEET OF

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER SB5
PROJECT Bioventing @ ST14
LOCATION POL Tank farm, Fuel loading area
DRILLING FIRM Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	no recovery	X	no recovery with splitspoons
	2-4'	no recovery		
5	3½-8½	5.0' recovery	black and dark olive gray clay, plastic, w/ medium and coarse gravel. no odors	OVA = 0 ppm core barrel destroyed.
			olive gray silty clay with some nodules, damp, no odors, ~~ox~~	FID Hydrogen tank empty - switch cylinder not functioning
			same as above	
10	8½-13½	~~4.0~~, 4.0 recovery	Olive gray fine sandy clay, moist very slight odors.	Sample SB5:10-11 collected at 10-10.5' bgs for TPH & BTEX.
			olive gray clayey fine sand, moist to wet, slight odors	
			TOTAL DEPTH = 13.5' bgs.	
15				
20				
25				

SHEET OF

DRILL LOG

CLIENT Carswell AFB WELL OR BORING NUMBER SB6
PROJECT Bioventing @ ST14 LOCATION POL Tank farm, fuel loading area
DRILLING FIRM Profile G.L. ELEVATION LOGGER BRV
DRILLING RIG CME75 HSA RIG OPERATOR Tom Placek
BEGINNING 22 June 1993 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED 12.0' AND FINAL
DATE: (22 June 93) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2'	2' recovery	dark olive gray to black clay. Very plastic, firm, damp	OVA scan = 0 ppm
	2-4	2' recovery	dark olive gray to olive gray silty clay w/ some small caliche nodules, plastic, damp, firm	Headspace @ 3' = 0 ppm OVA scan = 0 ppm
5	3½-8½	5.0' recovery	Same as above, damp, no odors	OVA = 0 ppm Headspace @ 7' = 0 ppm
			Olive gray to light olive gray sandy clay, plastic, firm, damp no odors, moist at below 8.5'	OVA scan = 0 ppm
10	8½-13½'	5.0' recovery		OVA scan = 0-10 ppm Headspace @ 10' = 12 ppm
			Olive gray clayey sand	
15			TD = 13.5'.	Sample SB6: 9-10' collected from sandy clay 9-10' for TPH & BTEX.
20				
25				

SHEET OF

DRILL LOG

CLIENT Carswell AFB
WELL OR BORING NUMBER SB7
PROJECT Bioventing @ ST14
LOCATION POL tank Farm, Fuel loading area
DRILLING FIRM Profile
G.L. ELEVATION
LOGGER BRV
DRILLING RIG CME 75 HSA
RIG OPERATOR Tom Placek
BEGINNING 24 June 93 AND END OF DRILLING AND CONSTRUCTION OPERATION
GROUNDWATER LEVEL FIRST ENCOUNTERED AND FINAL
DATE: ( ) ( )

DEPTH IN FEET	SAMPLING INTERVAL	GRAPHIC LOG	LITHOLOGIC AND CHARACTERISTIC DESCRIPTION	REMARKS: I.D. NO. OF SAMPLE TAKEN / RECOVERY (FEET) / OVA READING (PPM)
	0-2	no recovery	grass, loam & gravel in boot of spoon.	
	2-4'	1.0' recovery	dark olive gray to brown silty clay, slightly damp, firm, CaCO3 nodules	Headspace @ 3' = 0 ppm. OVA scan = 0 ppm
5	3½-8½'	4.0' recovery	brown to dark brown silty clay with small gravel and calcite nodules. no odors, mostly dry.	OVA scan = 0 ppm
			olive gray sandy clay, damp, no odors plastic	OVA scan = 0 ppm
10	8½-13½'	4.5' recovery		Sample SB7:11-12 collected @ 11.5-12' ~~1~~ for BTEX+TPH Headspace @ 11½' = 0 ppm
			olive gray clayey sand, wet no odors, OVA scan = 0 ppm.	
15			TD = 13.5' bgs	
20				
25				

Appendix E

Design Drawings and Specifications

GAST REGENAIR® Blowers
FOR SOIL VAPOR

designed to supply up to 420 cfm (714m 3/hr), 7 in Hg/224 mbar (90" H_2O) or 4 psi/249 mbar (100" H_2O)

The Gast reputation for quality and customer satisfaction is renowned throughout the world. Since 1921 we have been supplying air moving products that have set the industry standard of excellence. Our regenerative blowers for soil vapor extraction are no exception. Designed to extract vapors from contaminated soils, these models are used in conjunction with site-supplied special filters which clean the contaminants before venting them to the atmosphere. Since this process can take months or even years, Gast environmental blowers are a perfect solution; the only wearing part is the bearing, which is rated for up to 25,000 hours of service. Also, each of our motor-mounted models comes with a Class 1 Group D explosion-proof motor as a standard feature. Combining this quality with the strongest warranty in the business and a vast national and international distribution network providing product and technical support, we think you'll find our special Gast Regenair® blowers to be the right choice for your soil vapor extraction needs.

MODEL R4 SERIES
48" H_2O MAX. VAC., 51" H_2O MAX. PRESSURE
92 CFM OPEN FLOW

MODEL R5 SERIES
60" H_2O MAX. VAC., 65" H_2O MAX. PRESSURE
160 CFM OPEN FLOW

MODEL R6 SERIES
70" H_2O MAX. VAC., 75" H_2O MAX. PRESSURE
215 CFM OPEN FLOW

MODEL R6P SERIES
85" H_2O MAX. VAC., 100" H_2O MAX. PRESSURE
280 CFM OPEN FLOW

MODEL R7 SERIES
90" H_2O MAX. VAC., 90" H_2O MAX. PRESSURE
420 CFM OPEN FLOW

PRODUCT FEATURES
- Explosion-proof motors UL (class 1, group D)
- Sealed air stream
- Rugged construction
- Low maintenance

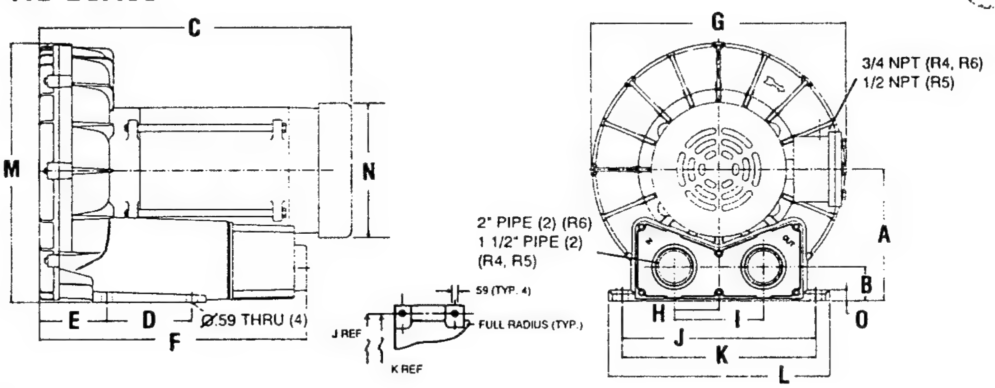
Product Dimensions

Metric (mm) / U.S. Imperial (inches)

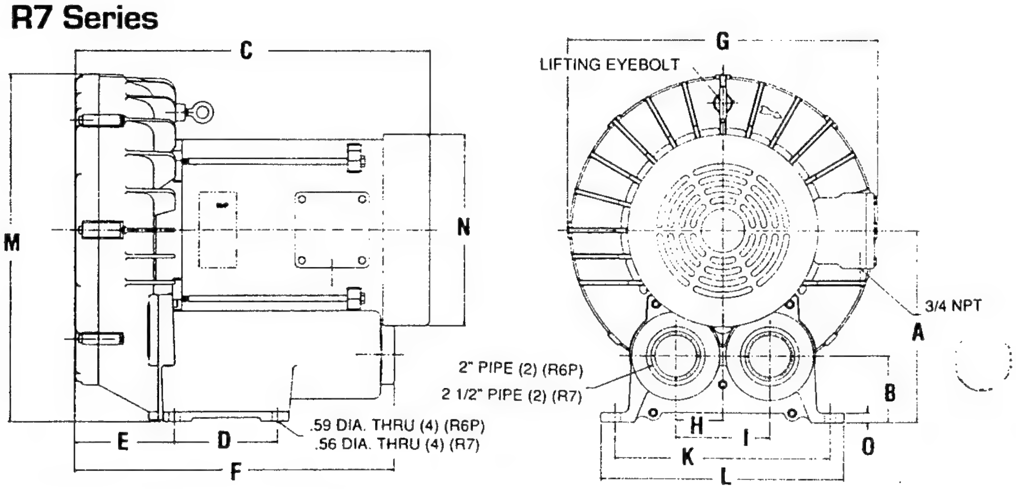
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
R4110N-50	157	43	389	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	15.30	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4310P-50	157	43	356	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.03	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R5125Q-50	178	46	445	114	91	361	344	60	121	260	262	298	350	173	15
	7.00	1.82	17.50	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	6.81	.59
R5325R-50	178	46	423	114	91	361	344	60	121	260	262	298	350	183	15
	7.00	1.82	16.66	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	7.19	.59
R6130Q-50	197	49	511	140	98	404	389	62	125	289	290	329	391	217	13
	7.75	1.94	20.13	5.50	3.85	15.89	15.30	2.46	4.92	11.38	11.42	12.96	15.38	8.56	.52
R6P1550Q-50	248	80	602	140	137	438	428	64	127	-	290	325	463	257	13
	9.77	3.15	23.7	5.51	5.39	17.25	16.87	2.50	5.00	-	11.42	12.80	18.21	10.12	.50
R6P355R-50	248	80	554	140	137	438	428	64	127	-	290	325	463	257	13
	9.77	3.15	21.80	5.51	5.39	17.25	16.87	2.50	5.00	-	11.42	12.80	18.21	10.12	.50
R7100R-50	274	92	577	216	212	545	457	100	200	-	375	410	509	257	14
	10.79	3.64	22.72	8.50	8.33	21.46	18.00	3.94	7.88	-	14.76	16.14	20.02	10.12	.56

Notice: Specifications subject to change without notice.

R4 Series
R5 Series
R6 Series



R6P Series
R7 Series



More models may be available – please consult factory

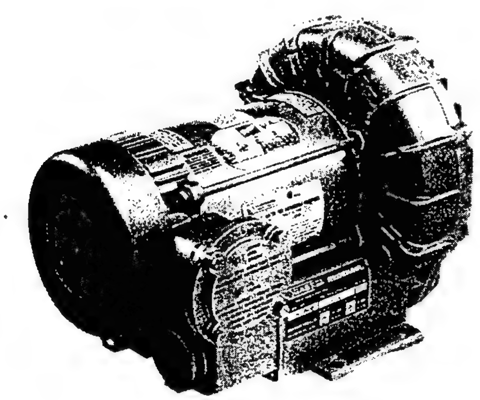
EXTRACTION...

Product Specifications

Model Number	Hz	Motor Specs	Full Load Amps	HP	RPM	Max Vac "H_2O	Max Vac mbar	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m³h	Net. Wt. lbs.	Net. Wt. kg.
R4110N-50	50	110/220-240-50-1*	9.2/5.2-4.6	0.6	2850	35	87	38	95	74	126	60	28
	60	115/208-230-60-1*	11.4/6.2-5.6	1.0	3450	48	120	51	127	92	156		
R4310P-50	50	220/380-50-3*	3.2/1.6	0.6	2850	35	87	38	95	74	126	58	27
	60	208-230/460-60-3*	3.4-3.3/1.65	1.0	3450	48	120	51	127	92	156		
R5125Q-50	60	115/230-60-1	25/12.5	2.0	3450	60	149	55	137	160	272	77	35
R5325R-50	50	190-220/380-415-50-3	5.0-4.4/2.5-2.6	1.5	2850	47	117	50	125	133	226	75	34
	60	208-230/460-60-3	6.0-5.6/2.8	2.0	3450	60	149	65	162	160	272		
R6130Q-50	50	220-240-50-1	14.7-13.5	2.5	2850	65	162	75	187	182	309	129	59
	60	230-60-1	16.3	3.0	3450	70	174	60	149	215	365		
R6P155Q-50	50	220-240-50-1	20.8-19.1	4.0	2850	65	162	80	199	235	399	243	110
	60	230-60-1	29.9	5.5	3450	85	212	95	237	280	476		
R6P355R-50	50	190-220/380-415-50-3	14.9-11/7.45-5.8	4.5	2850	65	162	80	199	232	394	233	105
	60	208-230/460-60-3	20-18/9	6.0	3450	85	212	100	249	280	476		
R7100R-50	50	190-220/380-415-50-3	20.8-18.9/10.4-9.5	8	2850	72	179	80	199	350	595	297	134
	60	208-230/460-60-3	26.5-24/12	10	3450	90	224	90	224	420	714		

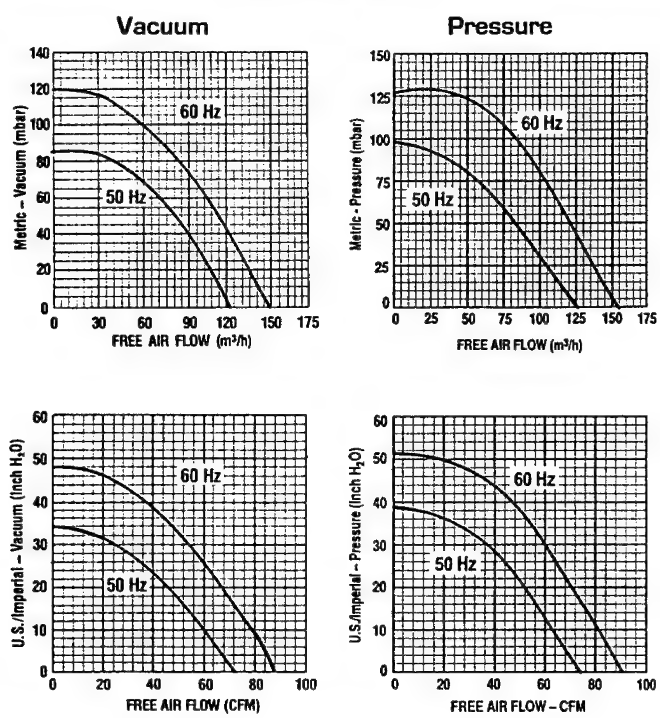
*Models have automatic reset thermal protection.

Product Performance
(Metric/U.S. Imperial)



NOTE: These units with explosion-proof motors are designed specifically for qualified OEMs in the soil vapor extraction industry. They are not intended to be applied for other uses without written acknowledgment from an authorized employee of Gast Manufacturing Corporation.

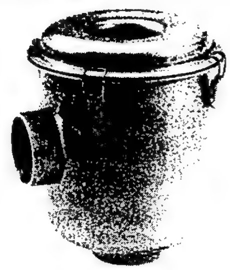
Model R4 Series



Blower Accessories

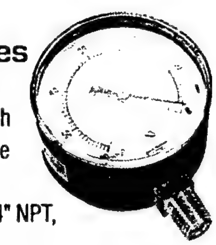
In-line Filters

The impeller of a blower passes very close to the housing. It is always wise to have an inlet or in-line filter to ensure troublefree life.



Model No.	R4	R5	R6,R6P	R7
Part No.	AJ151D	AJ151E	AJ151G	AJ151H
Replacement Element	AJ135E	AJ135F	AJ135G	AJ135C
Micron	10	10	10	10

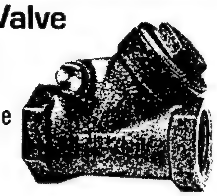
Vacuum and Pressure Gauges



To monitor the system performance so as not to exceed maximum duties. Using two (one on each side of the filter) is a great way to know when the filter needs servicing.

- Vacuum Gauge, Part #AJ497, 2 5/8" Dia., 1/4" NPT, 0-60 in. H_2O and 0-150 mbar
- Vacuum Gauge, Part #AE134, 2 5/8" Dia., 1/4" NPT, 0-160 in. H_2O and 0-400 mbar
- Pressure Gauge, Part #AJ496, 2 5/8" Dia., 1/4" NPT, 0-60 in. H_2O and 0-150 mbar
- Pressure Gauge, Part #AE133, 2 5/8" Dia., 1/4" NPT, 0-160 in. H_2O and 0-400 mbar
- Pressure Gauge, Part #AE133A, 2 5/8" Dia., 1/4" NPT, 0-200 in. H_2O

Horizontal Swing Type Check Valve



Designed to prevent back-wash of fluids that would enter the blower. Also prevents air back-streaming if needed. They can be mounted with their discharge either vertical or horizontal. Valve will open with 3" of water pressure.

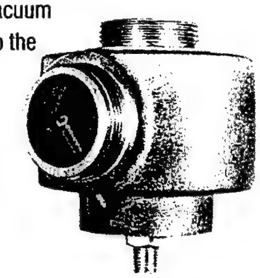
Model No.	R4,R5	R6,R6P	R7
Part No.	AH326D	AH326F	AH326G
	1 1/2" NPT	2" NPT	2 1/2" NPT

Moisture Separator

The purpose of the moisture separator is to remove liquids from the gas stream in a soil vapor extraction process. This helps protect the blower from corrosion and a build up of mineral deposits.

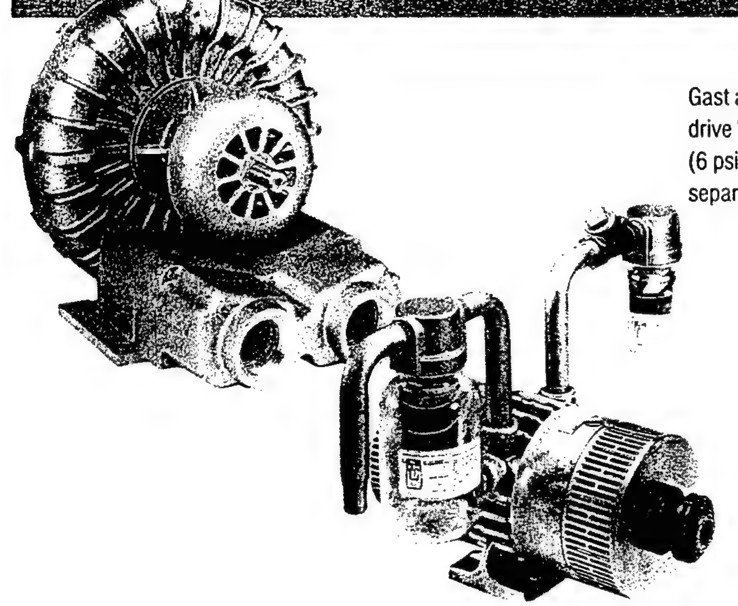
MODEL	LIQUID CAPACITY GALLONS	USED ON
RMS160	10	R4, R4P, R5
RMS200	19	R4, R4P, R5, R6
RMS300	19	R5, R6, R6P
RMS400	40	R6P, R7

Relief Valve

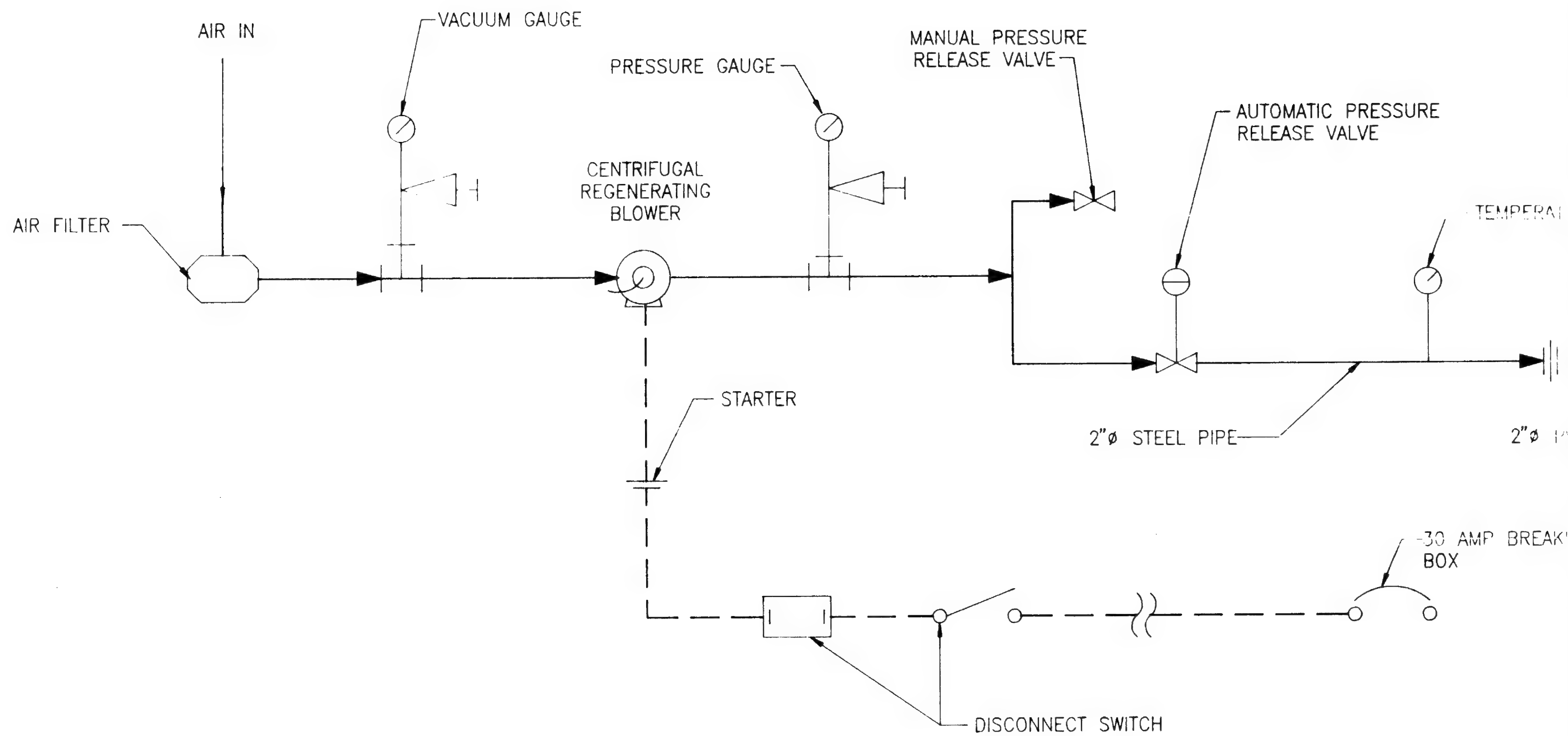


By setting a relief valve at a given pressure/vacuum you can be assured that no harm will come to the blower or products in your application from excessive duties.

- Pressure/Vacuum Relief Valve, 1 1/2" NPT, Adjustable 30 - 170 in. H_2O, 200 cfm max. Part #AG258



Gast also offers other models that are ideal for soil sparging. Our separate drive blowers are available in 4 sizes to 15 hp, pressures to 170" H_2O (6 psi). Rotary vane compressors are available in motor mounted or separate drive styles up to 5 hp, pressures to 20 psi.


AIR IN
AIR FILTER
VACUUM GAUGE
PRESSURE GAUGE
CENTRIFUGAL
REGENERATING
BLOWER
MANUAL PRESSURE
RELEASE VALVE
AUTOMATIC PRESSURE
RELEASE VALVE
2"ø STEEL PIPE
STARTER
DISCONNECT SWITCH
BOX

AIR INJECTION AND VENT WELL SYSTEM

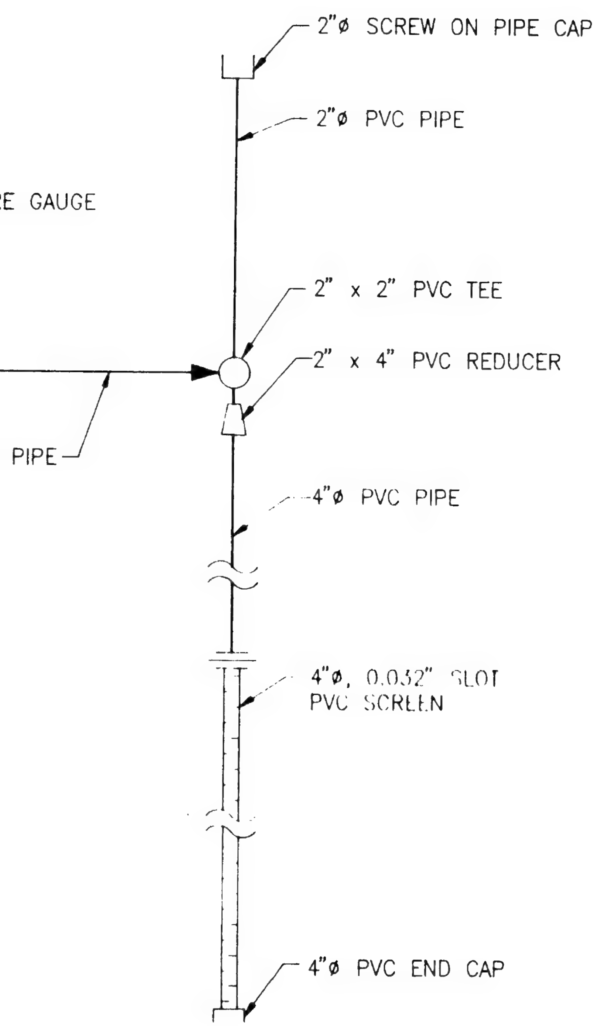
NOT TO SCALE

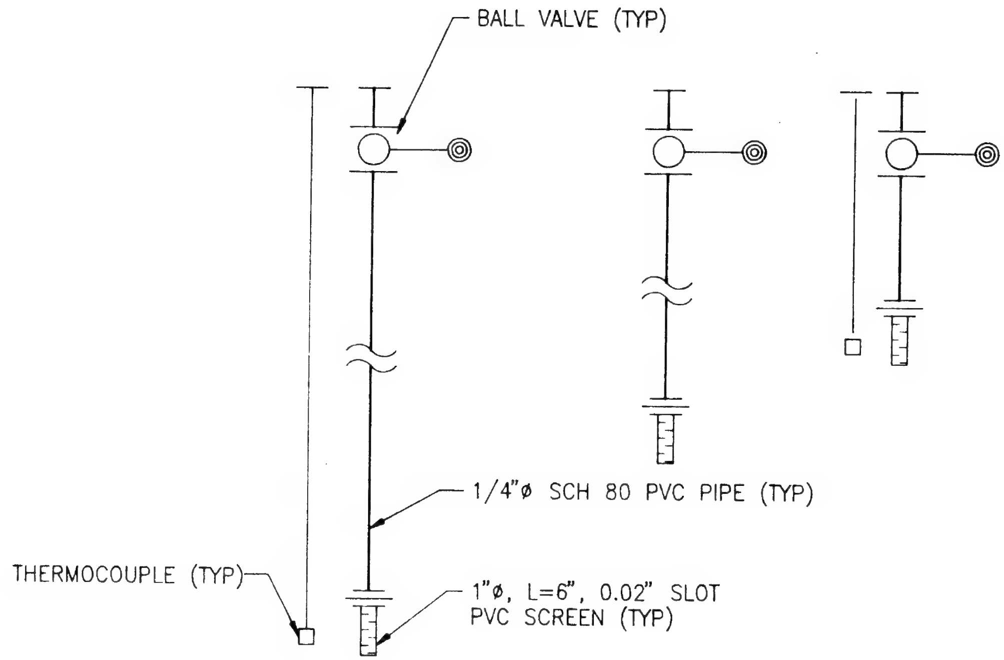
PIPING AND INSTRUMENTATION SCHEDULE

DESCRIPTION:	REMARKS:
BLOWER	1 HP GAST® REGENAIR R4110N-50
AIR FILTER	SOLBERG® MODEL F-30P-150
VACUUM GAUGE	0-60" OF H_2O VACUUM, MODEL AJ497
PRESSURE GAUGE	0-100" OF H_2O PRESSURE, NIKA 98518749
MANUAL PRESSURE RELEASE VALVE	1 1/2" GATE VALVE
AUTOMATIC PRESSURE RELEASE VALVE	GAST® AG258
TEMPERATURE GAUGE	0-250°F DIAL THERMOMETERS, MODEL 2A606
THERMOCOUPLES	1-4' AND 1-10', TYPE K:P-24-KT.
BALL VALVE	3/16" BALL VALVE
ELECTRICAL:	
STARTER	FURNAS® 14CSD33DA NEMA3, NO START/STOP, OVERLOAD SET AT 6 AMPS
DISCONNECT SWITCH	240V/ SINGLE PHASE, 30 AMP FUSED DISCONNECT
BREAKER BOX	30 AMP

2

VENT WELL-VW1

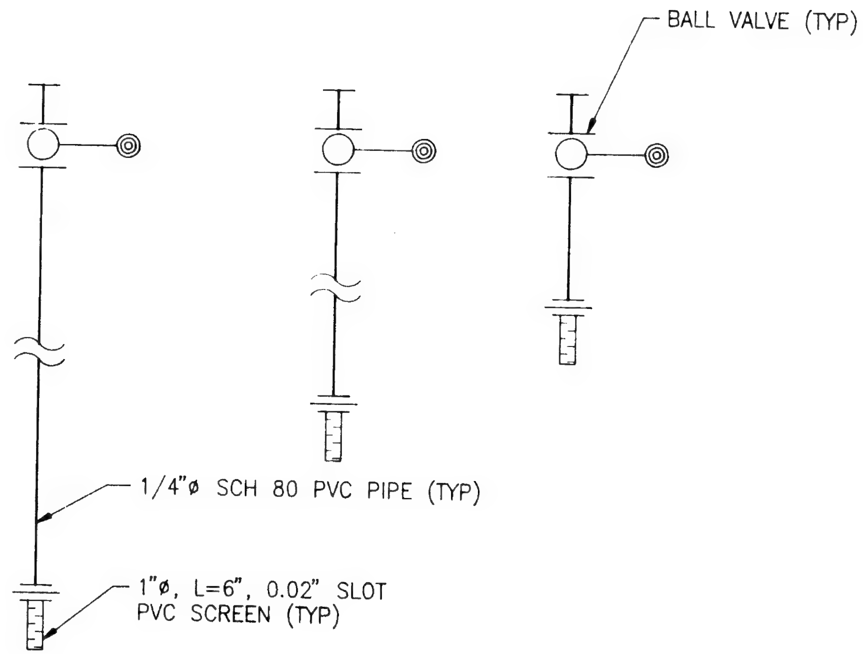




MONITORING POINT MPA

NOT TO SCALE

3



MONITORING POINTS MPB AND MPC (TYP)

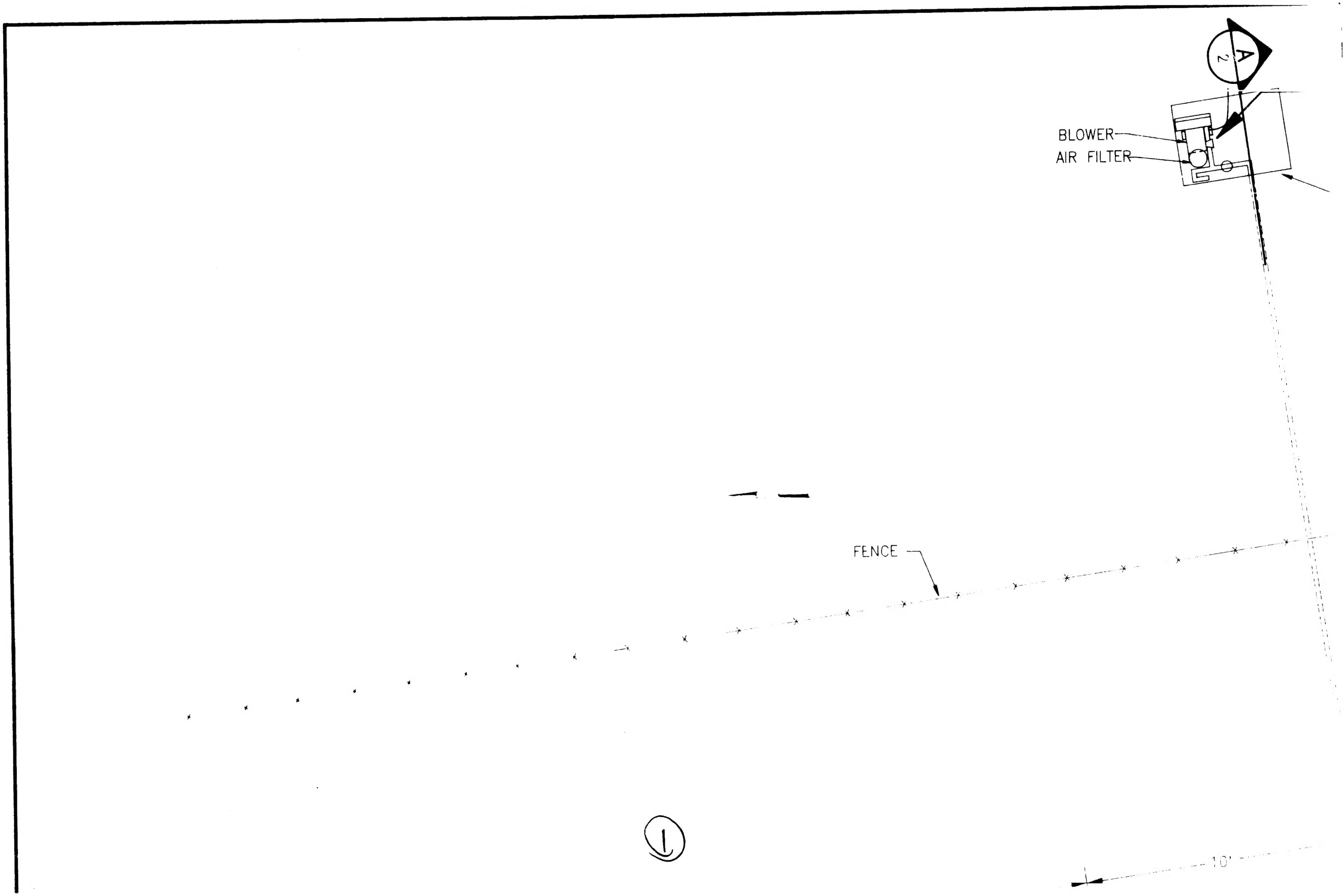
NOT TO SCALE

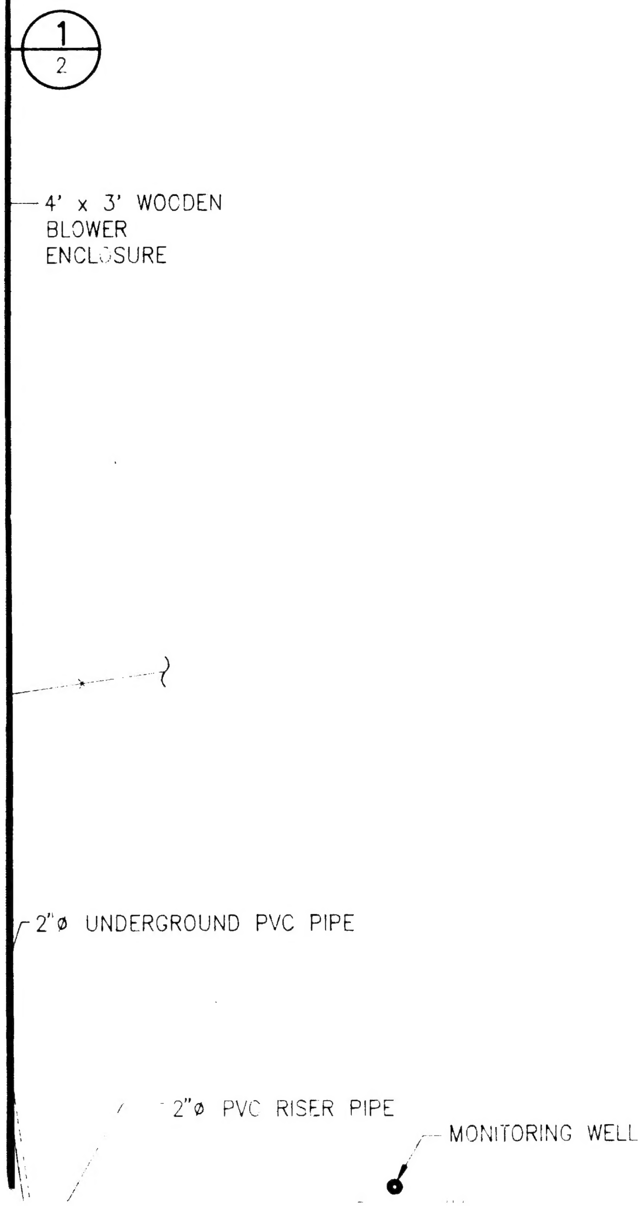
(4)

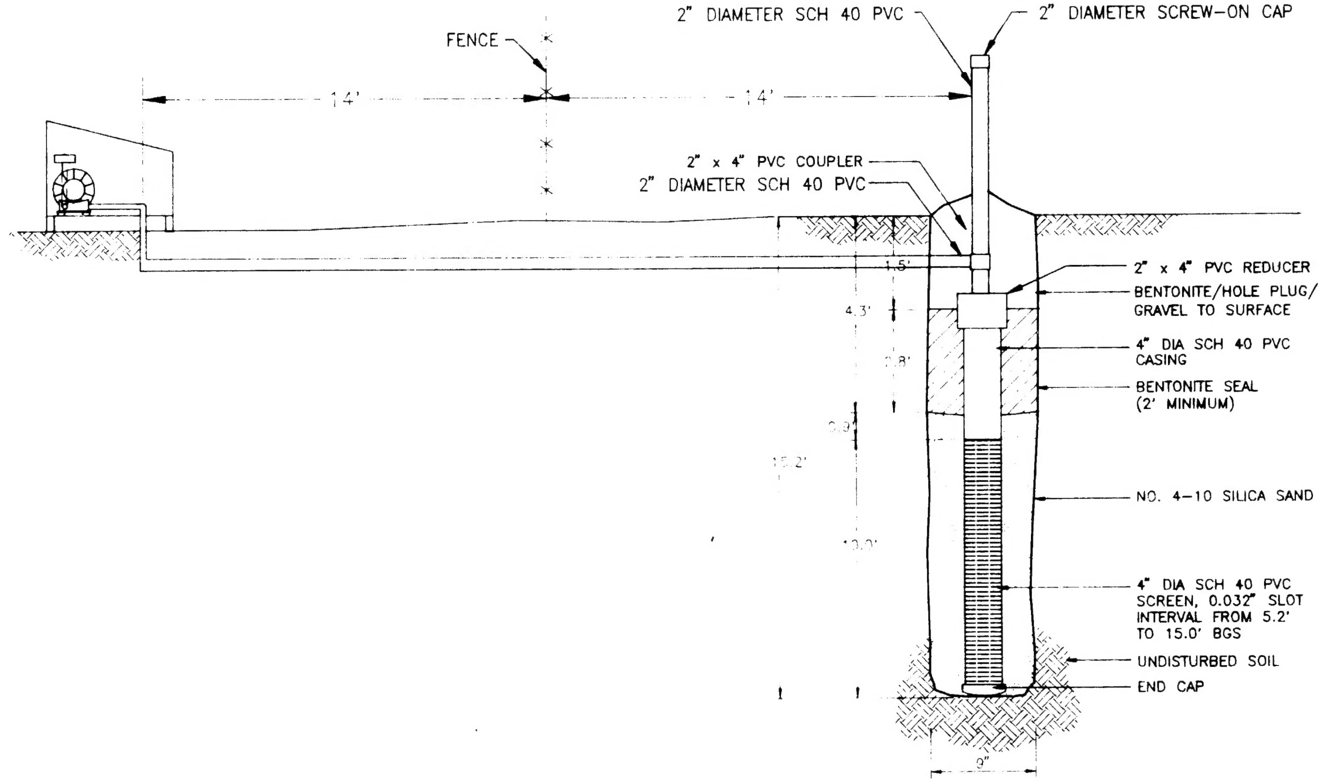
DRAFT

ENGINEERING-SCIENCE DESIGN + RESEARCH + PLANNING 7800 Shoal Creek Blvd. Suite 222W Austin, Texas 78757 512-467-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence
DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93	
DRAWN BY: CLG		
REVIEWED BY:	AS BUILT PROCESS FLOW, PIPING AND INSTRUMENTATION BIOVENTING SYSTEM	
SUBMITTED BY: J.D. HIGHLAND		
PLOT SCALE: NONE	DWG. CODE:	CONTRACT DATE: APRIL 30,1992
DESIGN FILE: AS-BTPFD		CALL ORDER NO.: 0004
PLOT DATE:	SHEET 1 OF 2	CONTRACT NO.: F41624-92-D-8036
		SHEET REFERENCE NUMBER 1

DRAFT DRAFT DRAFT


A
2
BLOWER
AIR FILTER
FENCE
10'
1



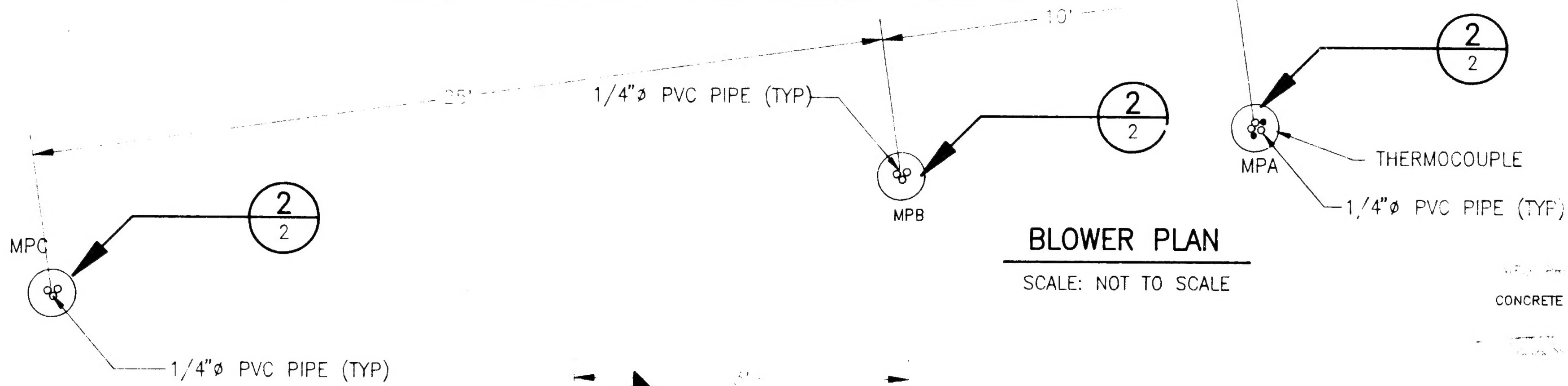


SECTION A–A'

SCALE: NOT TO SCALE

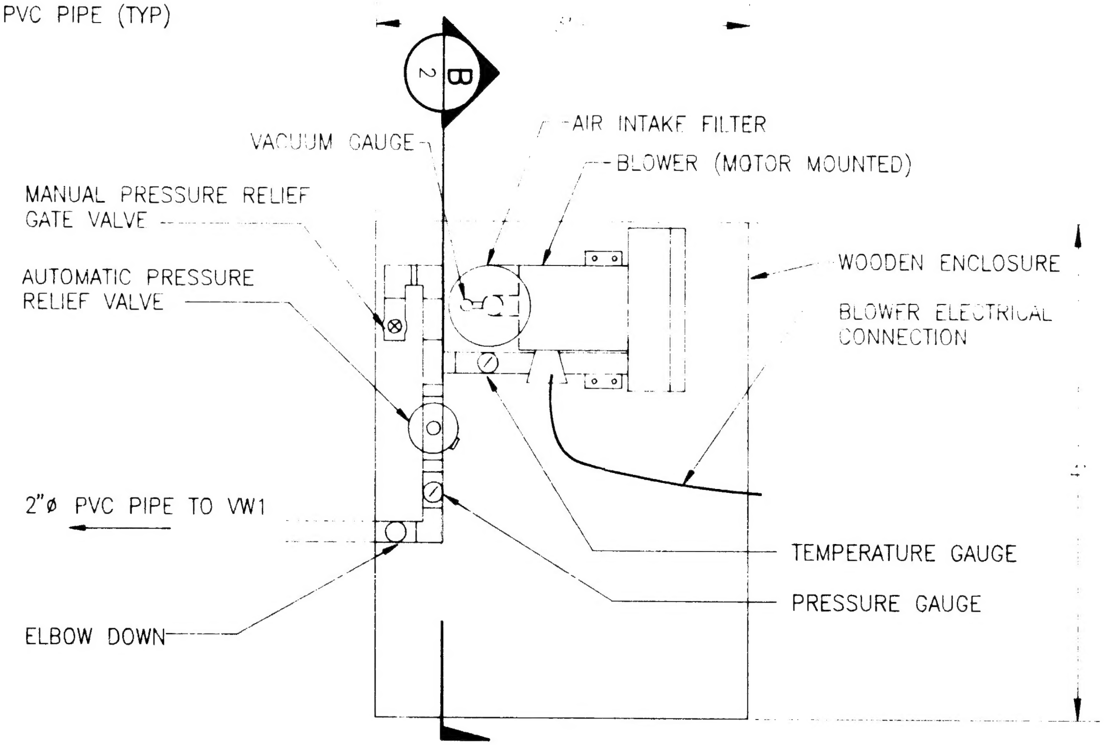
A
2

2



BLOWER PLAN

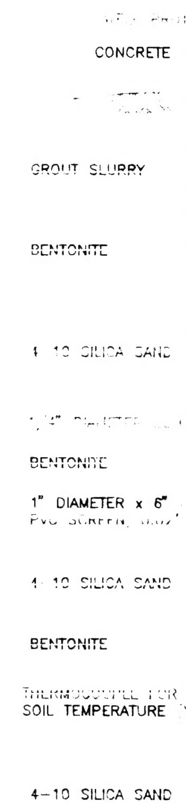
SCALE: NOT TO SCALE



BLOWER ASSEMBLY DETAIL

SCALE: NOT TO SCALE

1
2



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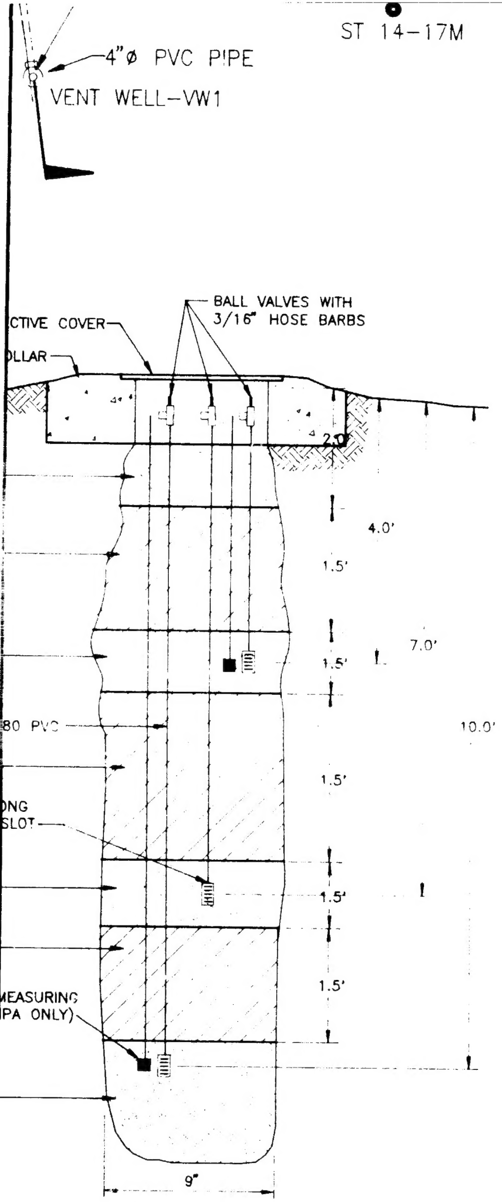
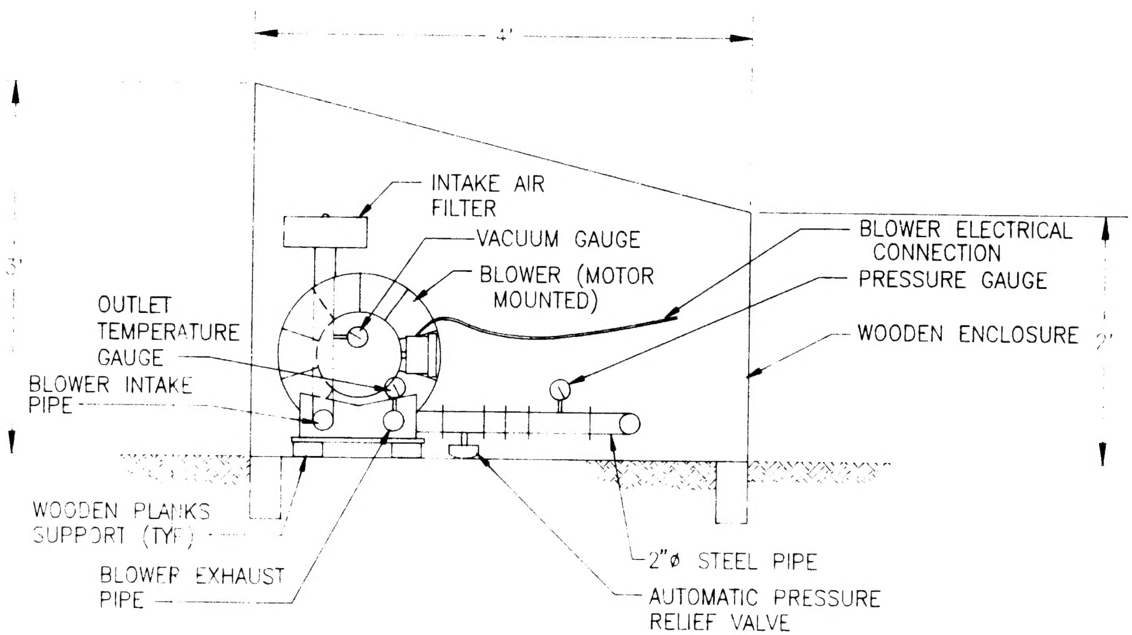


YPICAL DETAIL
MPA, MPB, & MPC)
CALE: NOT TO SCALE

2/2

NOTE:
THERMOCOUPLES WERE INSTALLED ONLY IN MONITORING POINT MPA. MONITORING POINTS MPB AND MPC DO NOT CONTAIN THERMOCOUPLES.



SECTION
SCALE: NOT TO SCALE

B/2

DRAFT

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ENGINEERING-SCIENCE DESIGN + RESEARCH + PLANNING 7800 Shoal Creek Blvd. Suite 222W Austin, Texas 78757 512-467-6200 Offices in Principal Cities	ES	U.S. Air Force Center for Environmental Excellence	
DESIGNED BY:	CARSWELL AIR FORCE BASE FORT WORTH, TEXAS PN:FY7624-93-08030 FY:93 DRAFT AS--BUILT PLAN, SECTIONS AND DETAILS OF BIOVENTING SYSTEM		
DRAWN BY: CLG			
REVIEWED BY:			
SUBMITTED BY: J.D. HIGHLAND			
PLOT SCALE: AS NOTED	DWG. CODE:	CONTRACT DATE: APRIL 30,1992	SHEET REFERENCE NUMBER 2
DESIGN FILE: PLAN-SCT		CALL ORDER NO.: 0004	
PLOT DATE:	SHEET 2 OF 2	CONTRACT NO.: F41624-92-D-8036	